Ch 3

CHAPTER 3. Affected Environment

DESCRIPTION OF STUDY AREAS

Sacramento River Service Area

The general location of the SRSA is shown in Figure 1-1. The SRSA affected environment is described in this chapter. The content and length of the affected environments descriptions contained in this chapter are determined by the significant resource issues identified in the Scoping process. These significant issues are summarized in Chapter 1 of the EIS and in the introductions for the impacts analysis for each resource category in Chapter 4.

Site-Specific Service Areas

As described in Chapter 2, Reclamation received requests from many agencies for new and expanded CVP water service contracts. The locations of these agencies are shown in Figures 2-4 - 2-6. In response to these requests, Reclamation required these agencies to submit information describing how the water would be used and what new site-specific water-related facilities would be required to provide the water to users in the service area. Reclamation also required the agencies to provide information pertaining to land use and population changes expected to occur so that the relationship of the CVP water contracting programs to those changes could be assessed.

Table 3A-1 briefly indicates what is known about proposed development within each requesting agency. Specific information regarding current water and land uses is included in the appropriate sections of this chapter. Information regarding anticipated 2020 water and land uses for each agency and the impacts of those uses are described in Chapter 4, "Environmental Consequences."

Table 3A-1. Site-Specific Service Area Information:

Sacramento River Service Area

Agency	Proposed Land Conversions[a]: To Urban Uses	Proposed Land Conversions[a]: To Irrigated Agricultural/ Wetland Uses[a]	Additional Facilities Needed to Use CVP Water: Treatment	Additional Facilities Needed to Use CVP Water: Distribution
Shasta Dam Area PUD	X		X	X
Sacramento Valley Canals Agencies				
Colusa County WD				
Corning WD		X		X
Dunnigan WD		X		
Glenn-Colusa ID		X		X
Glen County Lands				
Glide WD		X		X
Kanawha WD		X		X
Orland-Artois WD		X		X
Willow Creek MW Co.		X		X
Holthouse WD		X		X
Orland-Artois WD		X		X
Rancho Saucos WD		X		
Tehama Ranch MW Co.		X		
Yolo-Zamora WD		X		X
Yolo-Solano CVP Water Service Coordinating Group				
Yolo County FC&WCD		X		X
Davis, City of	X		X	X
Woodland, City of	X		X	X
Solano County	X		X	X
Refuges				
Colusa NWR		X		
Delevan NWR		X		
Gray Lodge WMA		X		
Sacramento NWR		X		
Sutter NWR		X		

[a] Only refuges and the Willow Creek Mutual Water Company are proposing to create wetland areas with CVP water.

SOILS AND DRAINAGE

Sacramento River Service Area

Introduction

This section describes the soils and drainage resources of the SRSA. It focuses primarily on the quantity and quality of irrigation return flows occurring within the area, which are discharged to the Sacramento River and its tributaries. Particular emphasis is placed on the Colusa Basin Drain (CBD) because it receives the majority of return flows from the area and because records of its discharge and water quality data are available. Drainage water quality focuses on salinity, boron and rice herbicide levels and selected trace elements because these (characteristics are important concerns with respect to many designated beneficial uses (see "Surface Water Quality) and could change as a result of water contracting. Refuges are addressed very generally due to the lack of available information regarding existing drainage facilities and practices. Information regarding land classification in the SRSA is presented in the "Land Use" section of this chapter.

Soils and Geomorphology

The floor of the Sacramento Valley is composed of mixed sedimentary and igneous alluvium deposited during the Holocene and late Pleistocene age. Four major geomorphic surfaces or units occur within the SRSA. Progressing from the center to the western edge of the valley, there are recent alluvium, flood basins, alluvial plains and terraces, and the rolling uplands and hills along the west side of the valley.

The recent alluvium unit includes materials from the stream channels, floodplains, and natural levees of the Sacramento and Feather Rivers and their tributaries. Coarse-grained material, sand, and gravel are characteristic along the stream channels and natural levees. Sands and silts of the floodplain have also been deposited near the active channels. However, these deposits grade from coarse textures near the river to fine textures near the flood basin. The recent alluvium unit is topographically elevated above the flood basin unit.

The flood basins form a nearly flat trough bounded between the alluvial plains and dissected terraces and the slightly elevated recent alluvium of the Sacramento River and tributaries. Before artificial levees were constructed, floodwaters containing fine-grained sediments frequently spilled over into the low-lying areas next to the river. Unconsolidated silt and clay are predominant basin materials, although fine sands occur along the contact with the recent alluvium unit.

The alluvial plains and dissected terraces are situated between the flood basins adjacent to the Sacramento River and the foothills adjacent to the uplands of the Coast Ranges. The alluvial plain is in equilibrium between erosion and deposition as evidenced by the extensive hardpan in the subsoil.

Soils in the upland/rolling foothills unit formed in place and are underlain by mostly sedimentary rock. The upland areas generally occur on the western perimeter of the valley and are topographically above the terrace lands. Many of the soils are fine textured and shallow, underlain by sedimentary materials.

Typical soil series found in each geomorphic unit are: uplands/rolling foothills -- Auburn and Argonaut; alluvial plains and dissected terraces -- San Joaquin, Redding, and Corning; flood basins -- Clear Lake, Sacramento, and Willows; and recent alluvium -- Hanford and Honcut.

Surface Drainage

Agricultural drainage and storm runoff from the SRSA is discharged to the Sacramento River through a complex system of natural and artificial open channels. This drainage system operates on a farm, district, and regional basis to collect surface runoff and shallow groundwater and carry them out of the agricultural area.

The major natural streams that discharge to the Sacramento River are Thomes and Stony Creeks in the northern CVP area and Cache and Putah Creeks in the southern CVP area (Cache and Putah discharge to the Yolo bypass, which discharges to the Sacramento River near Rio Vista).

Agricultural drainage occurs primarily in April through September. Storm runoff occurs in October through March.

A major portion of the SRSA is served by the artificial CBD, which discharges by gravity to the Sacramento River near Knights Landing or when the river is too high, to the Yolo bypass through the Knights Landing ridge cut. The CBD receives drainage from many artificial surface drains as well as numerous natural, primarily ephemeral, streams that flow out of the Coast Ranges. In addition to providing drainage, the CBD serves as a water supply for nearby lands. Private irrigators pump out of the CBD, apply the water to the land, and discharge drainage back to the drain. In this manner, the CBD facilitates reuse of agricultural drainage, tending to increase irrigation efficiency on a regional basis. Reuse of agricultural drainage also occurs at the farm and district levels.

Subsurface Drainage

Although much of the SRSA is affected by shallow groundwater, there are few artificial subsurface drainage systems. Instead, many of these areas are cropped to rice, avoiding the need for subsurface drainage. Orchards and annual row crops that must be well drained are generally planted on soils, such as the alluvial fan soils, that have adequate natural drainage or have artificial drains installed.

The predominant surface and subsurface drainage flow that reaches the Sacramento River is through the CBD. Average annual CBD discharge is 323,674 af, with 251,710 af (78 percent) occurring during the irrigation season and 71,964 af (22 percent) occurring during the nonirrigation season (see Table 3B-1).

Table 3B-1. Average Monthly Colusa Basin Drain Discharge at Knights Landing (in af)

	Irrigation Season			Nonirrigation Season	
	April	11,958		October	17,990
	May	36,916		November	16,517
	June	19,429		December	7,161
	July	37,662		January	13,069
	August	69,080		February	10,223
	September	76,665		March	7,004
Subtotals		251,710			71,964
% of Total		78			22
Total			323,674		

Note: Derived from daily flow records from 1976-85.

The portion of CBD flow attributable to subsurface drainage has not been determined; however, it is known that the release of ponded water from rice fields in late August and September causes the larger flows in those months. Irrigation season flows account for 78 percent of the annual average; nonirrigation season flows account for the remaining 22 percent.

Drainage Water Quality

Salinity and Boron. Most of the flow in the CBD during the irrigation season is agricultural return flow, and the CBD carries return flow from a large portion of the SRSA. Therefore, water quality information for the CBD at Knights Landing (Table 3B-2) was used to characterize the quality of return flow from SRSA agricultural land for existing (1985) conditions.

Table 3B-2. Colusa Basin Drain and Sacramento River Water Quality

Location	EC[a] (μmhos/cm)	TDS[b] (ppm)	B (ppm)
Colusa Basin Drain at Knights Landing at Knights Landing			
Irrigation season (Apr through Sept)	442	283	0.22
Nonirrigation season (Oct through Mar)	830	531	0.17
Annual average	636	407	0.20
Sacramento River			
Red Bluff Diversion	127	81	0.05
Knights Landing above the CBD	159	102	0.06
Knights Landing below the CBD	187	120	0.07

Note: Derived from DWR and USGS water quality data.
[a]EC = Electrical conductivity (in micromhos per centimeter)
[b]TDS = Total dissolved solids (in parts per million): Calculation based on TDS = 0.64 x EC

In combination with discharge data, these water quality data indicate that approximately 150,000 tons of salt are discharged from the CBD to the Sacramento River each year.

The quality of water in the Sacramento River is degraded as it flows from Red Bluff to Knights Landing due, in part, to agricultural return flow (see Table 3B-2). Comparing water quality data upstream and downstream of the CBD, it is evident that the impact on total dissolved solids (TDS) from the drain (difference between Knights Landing above and below the drain) is about the same as from all return flow to the Sacramento River from the Red Bluff Diversion to Knights Landing. Differences in boron concentrations are insignificant.

Trace Elements. Specific data on trace elements in both drainage waters and soils in the SRSA are limited. In the lower Sacramento Valley land classification conducted by CH2M Hill (1987), soil and drainage water samples were analyzed for a number of trace elements including arsenic, selenium and cadmium. Total arsenic and selenium analyses of that limited sampling indicated soil ranges for arsenic to be 2.3-25 mg/kg, which is at the lower end of the normal range of 1.8-800 mg/kg found in naturally occurring soils. The total selenium levels ranged from <0.2 (detection limit 0.2) to 1.5 mg/kg again at the low end of the naturally occurring soils, - 0-100 mg/kg (Goering, 1986a and 1986b).

Additional analyses of water soluble arsenia and selenium were conducted. The general conclusion reached from these analyses is that although the total arsenic and selenium may be significant, other extractant analyses indicate trace elements are extremely low. Drainage water quality samples from Sycamore Slough (tributary to CBD) showed arsenic levels ranging from 0.005 to 0.019 mg/L and selenium all below detection limits of 0.005 mg/L.

The lower Sacramento Valley is primarily basin lands that have formed from pedologically recent alluvial deposition that eroded from the upper Sacramento watershed. Since these basin lands have low concentrations of trace elements in both the soils and drainage waters, the conclusion can be made that the rest of the SRSA has probably even lower trace element levels.

Rice Herbicides. During the early 1980s, pesticide contamination of the Sacramento River resulted in annual fish kills and drinking water complaints from City of Sacramento water users. Two primary rice herbicides, molinate (Ordram) and thiobencarb (Bolero), have been linked to the irrigation return flows in the Sacramento River system. Cooperative efforts among the California DFG, and the Departments of Health Services and Food and Agriculture, and the Regional Water Quality Control Board, Central Valley Region (RWQCB), and rice growers have resulted in establishment of discharge limits, distributor sales limitations, and water management practices. The cooperative effort has 1) reduced the use of these herbicides, 2) increased onfarm water recycling to meet herbicide decay life, and 3) resulted in Sacramento River discharge limits being met (California Department of Food and Agriculture 1987).

Site-Specific Service Areas

Sacramento Valley Canals Agencies

Soils. The Sacramento Valley canals agencies are characterized by geomorphic units such as old terraces, alluvial fans, narrow floodplains, and major flood basins. The area is characteristically composed of nearly level farmland, with a diversity of agricultural production including rice, orchards, and row crops.

In the major flood basin areas in districts such as Willow Creek and Glenn-Colusa, the dominant soils are the Clear Lake, Sacramento, and Willows series. In these closed basin (topographically low) areas, extensive drainage facilities and salinity/alkalinity management practices have been developed to sustain clayey soils for productive agriculture (primarily rice production).

Surface Drainage. In this area, some or all runoff of applied irrigation water (tailwater) is captured and reused for irrigation. Tailwater reuse facilities are commonly owned and operated at the farm level but some are at the district level. Typical farm tailwater systems consist of a pond located at the tail end of one or more fields that receives gravity tailwater flows, and a pump and pipeline system for recycling water to the head of the field. Most districts encourage farmers to construct and use such systems for water conservation purposes. A number of systems have been implemented in the last several years as awareness of water conservation has grown and water costs have increased. Meetings with the water districts yielded the facilities inventory summarized in Table 3B-3.

Subsurface Drainage. Although a major portion of the area is affected by shallow groundwater, there are few subsurface artificial drainage systems, as indicated in Table 3B-3.

Drainage Water Quality. Site-specific drainage water quality data are very limited. However, the CBD quality data, including trace elements, presented in the regional discussion are considered reasonably representative of the quality of drainage from individual districts. An exception may be the Yolo-Zamora Water District, which uses some high boron groundwater (>0.75 ppm) and, consequently, probably has higher boron concentrations in surface and subsurface return flows.

Yolo-Solano CVP Water Service Coordinating Group

Soils. As the only requesting agricultural water user in the Yolo-Solano area, the Yolo County Flood Control and Water Conservation District is characterized by geomorphic units such as rolling upland/hills, narrow floodplains, alluvial fans, and dissected terraces. It is bounded on the west by the steeper upland Coast Ranges and on the east by the Sacramento River floodplain areas. Irrigated agriculture is diverse in the area, supporting row crops, orchards, and some rice along the eastern edge of the district, in and adjacent to the Yolo Bypass. The service area contains the communities of Davis, Woodland, and others, with irrigated farmland interspersed.

Some of the alluvial fan soils, particularly those in the Cache Creek area, are known to contain significant levels of boron. Specific cropping and management practices have been developed to minimize the impacts of these elevated boron levels.

Surface Drainage. Yolo County Flood Control and Water Conservation District has natural surface drainage through Cache and Putah Creeks, both of which flow into the Yolo Bypass. However, no significant amounts of tailwater flow reach the Sacramento River because nearly all irrigation tailwater is reused for irrigation within the district.

Subsurface Drainage. In the Yolo County Flood Control and Water Conservation District shallow groundwater is not currently a problem and there are, therefore, few subsurface drainage facilities.

Drainage Water Quality. Because return flow is reused and no significant amount of flow reaches the Sacramento River, drainage water quality for the district has not been determined.

Refuges

Soils. Within the SRSA, five wildlife refuges are interspersed in major irrigated agricultural areas. All of the refuges are located in the closed basin landform on the Clear Lake, Sacramento, and Willows soils series (SCS association), which are well suited to the

Table 3B-3. Agricultural Drainage Facilities:

Sacramento River Service Area

Agency	Surface Drainage Facilities/Outlet	Surface Water Reuse Systems District	Surface Water Reuse Systems On-farm
Colusa County Water District	Several natural creeks to Colusa Basin Drain (CBD)	None	Many on-farm systems, especially on rice
Corning Water District	Burch, Jewett, and other creeks to Sacramento River	None	Some on-farm systems
Dunnigan Water District	Various natural creeks and artificial drains to CBD	None	Few on-farm systems
Glenn-Colusa Irrigation District	Various natural creeks and artificial drains to CBD	Davis weir reuse system	Few on-farm systems on developed land, none on land presently dryland and farmed
Yolo-Zamora Water District	CBD or to Yolo Bypass	None	Some on-farm systems
Glide Water District	Storm drainage to Willow Creek, then to CBD	Yes; all irrigation tailwater reused	Very few on-farm systems
Holthouse Water District	Wilson Creek to CBD	None	Two on-farm systems
Orland-Artois Water District	Various natural creeks to CBD	None constructed; feasibility investigations in progress	Some on-farm systems
Rancho Saucos Water District	Storm drainage to Sacramento River	District tailwater collection and reuse system; all irrigation tailwater reused	One-owner district-farm and district coincide
Tehama Ranch Mutual Water Company	Natural creeks to Sacramento River	Yes - negligible surface runoff from District	One-owner district-farm and district coincide
Yolo County Flood Control and Water Conservation District	Cache, Putah, and various other natural creeks to Yolo Bypass	Reuse throughout delivery system	Some on-farm systems
<u>Glenn County Lands</u>			
Glide Water District	Willow Creek to CBD	None	None - presently dryland farmed
Kanawha Water District	Willow Creek to CBD	None	None - presently dryland farmed
Orland-Artois Water District	Willow Creek to CBD	None	None - presently dryland farmed
Willow Creek Mutual Water District	Willow Creek to CBD	None	None - presently dryland farmed

ponded wetland habitat. Many of the refuges have mixed habitat for native marshes, intermixed with irrigated agricultural lands developed specifically for wildlife/waterfowl food production.

Surface and Subsurface Drainage. All of the refuges are located in the basin area and tend to have shallow water tables and poor drainage. The refuges have varying water supplies, and each discharges return flow into open-ditch systems. No significant subsurface drainage facilities have been or will be developed in these areas because they are not desirable for the wetland habitat.

Drainage Water Quality. Drainage water quality specifically for refuge return flows has not been determined. However, this return flow constitutes one source of salts and other chemical constituents in determining the ultimate quality of CBD and Sacramento River flows.

SURFACE WATER HYDROLOGY AND SEEPAGE

Sacramento River Service Area

Introduction

This section describes the surface water hydrology of the SRSA. It focuses on CVP facilities in the upper Sacramento River Basin, the upper Trinity River Basin and the Sacramento River from Keswick to the Delta, because these are the facilities and river system that would be used to supply and deliver water under the contracting alternatives considered in this EIS.

Agencies requesting CVP water in the SRSA are located within an area that extends from Shasta Dam near Redding in the north, to the Delta in the south, a distance of some 200 miles. The service area includes the western side of the Sacramento Valley, varying in width to about 30 miles.

Natural Hydrologic Features

Runoff from the upper Sacramento River watershed of the northern Sierra and southern Cascade mountains is conveyed to the Delta by the Sacramento River and its tributaries to the Delta.

Major tributaries of the Sacramento River above its confluence with the American River are the Pit, McCloud, and Feather Rivers. Other tributaries include Clear, Cottonwood, Battle, Mill, Deer, Thomes, Stony, and Cache. The Yuba and Bear Rivers are major tributaries to the Feather River above its confluence with the Sacramento. Major natural lakes in the Sacramento River basin include Goose Lake at the headwaters of the Pit River, Lake Almanor high in the Feather River drainage, and Clear Lake in the Cache Creek drainage (Almanor and Clear Lakes have been enlarged by dams constructed by Pacific Gas and Electric Company and Yolo County Flood Control and Water Conservation District, respectively).

Over the years the bed and banks of the Sacramento River have been built up by sediment deposition, until at the present time the elevation of the river is higher than adjacent lands. This condition has led to the formation of a secondary drainage system in which drainage from valley floor lands is carried along with river flow in drainage channels parallel to the river. The Colusa Basin Drain drains the valley floor west of the river between Stony Creek on the north and Cache Creek on the south. The drain discharges to the river at Knights Landing during the irrigation season, and to the Yolo Bypass in the nonirrigation season. A similar trough exists in the Butte Basin on the east side of the river. During 1984, the Colusa Drain returned about 27 percent of the diverted water to the river.

Water Resources Development

Central Valley Project. Features of the CVP in the Sacramento and Trinity basins include water storage and power production facilities of the Shasta/Trinity Division, pumping and conveyance facilities of the Sacramento Canals Unit of the Sacramento River Division, and drainage facilities for the areas served CVP facilities of the SRSA are described in the "Description of Major CVP Facilities" section of Chapter 1.

California State Water Project. The SWP, built and operated by DWR, is similar in some ways to the CVP. Both projects store runoff in the Sacramento Valley basin, release stored water to the Sacramento River and the Delta, and pump water out of the southern Delta for delivery to water users to the south and west. SWP's storage facilities are on the Feather River, and its facilities for distributing water from the Delta extend farther south than those of the CVP.

The uppermost facilities of the SWP are three small reservoirs: Davis, Frenchman, and Antelope located high on separate forks of the Feather River. The forks meet at Oroville Reservoir, the project's principal storage facility. Water released from Oroville is used to generate electrical power in the Hyatt-Thermalito complex downstream. Below the Thermalito Afterbay outlet, releases continue down the Feather River, which joins the Sacramento River 21 miles above Sacramento. Here, waters managed by the SWP mingle with and become indistinguishable from the waters of the CVP. Water from the two projects flow commingled into the Delta.

The SWP operates Harvey O. Banks Pumping Plant and Clifton Court Forebay in the southern Delta. The forebay takes in Delta water as the high tide recedes; then its gates are closed, and the plant pumps from the forebay for export to the SWP service areas in the South Bay, Tulare Lake basin, and southern California.

Existing Hydrologic Conditions in the Sacramento River Region

Streamflows. The average yearly flow and volumes for each of the major tributaries to the Sacramento River above its confluence with the American River, and the Sacramento River at the Delta, are shown in Table 3C-1.

The flows within the basin generally peak in April and May of each year with basin snowmelt. Normal summer flows in most creeks that drain the west side of the basin are very small compared to the peak runoff flows. Flows in the larger tributaries fall off during the summer as well, but remain somewhat higher due to upstream storage releases to the Delta for export to the southern part of the state.

Reservoirs. There are reservoirs on nearly all the streams and rivers in the basin. The major ones are Shasta and Oroville. Flows diverted from the Trinity River basin are stored in Clair Engle Reservoir. Storage capacities of these reservoirs are shown in Table 3C-2.

Table 3C-1. Average Flow Conditions of Selected Streams: Sacramento River Service Area

Stream or River	USGS Station	Average Flow (cfs)	Average Volume (af)	Water Years
Spring Creek (includes Trinity Diversions)	11371600	1,935	1,402,000	1965-86
Clear Creek	11372000	549	397,800	1963-86
Cottonwood Creek	11376000	899	651,300	1940-86
Stony Creek	11388000	688	498,000	1956-86
Cache Creek	11452500	551	399,200	1903-86
Feather River	11407150	5,417	3,925,000	1964-86
Trinity Diversions	11525430	1,542	1,117,000	1963-86
Sacramento River	11447650	24,600	17,823,000	1949-86

26,213,300 af
av. volume

Note: Data from USGS Water Data Report CA-86-4.

Table 3C-2. Maximum Capacity of Major Reservoirs

Reservoir	Storage (1,000 af)
Whiskeytown	241
Shasta	4,552
Keswick	24
Feather Oroville	3,538
Clair Engle	2,448
Lewiston	15
Spring Creek	6

10,824 (1000 af)

C-055549

Seepage

The Sacramento River system has been extensively leveed in the valley to contain flood waters resulting primarily from snowmelt in the Cascades and Sierra Nevada and from intense rainfall on tributary watersheds. During periods of high runoff, the waters confined within the levees are frequently higher than the surface of adjoining lands. When this occurs for more than a short period of time, water seeps under and through the levees, saturating the lands abutting the levees and often ponding on the land surface.

Historical Seepage Conditions. Prior to construction of levees along the river channels in the Sacramento Valley, floodwaters often nearly covered the valley in a continuous sheet, overflowing the natural levees that had been built up by the rivers. Early efforts at land reclamation consisted of construction of low levees on top of the natural levees. These levees confined floodwaters within narrower bounds, increasing elevations of the head of water against the levees. This situation caused an increase in seepage through and under the natural levees. When the stage increased sufficiently, seepage also occurred through the manmade levees. Basically, seepage occurs when the differential head between the water surface in a leveed channel and the groundwater table in hydraulic continuity with the water in the channel is maintained long enough to cause the groundwater level to rise into the crop root zone.

Area Affected. Very little seepage occurs north of Hamilton City because the land generally lies above river level. Seepage south of the city of Sacramento is considered part of the Delta area subject to tidal fluctuations and complex hydraulic conditions. Most of the seepage occurs between Colusa and Sacramento. The area affected varies from year to year depending on the stage and duration characteristics of the particular year in question. Related seepage damage also varies depending on stage and duration as well as time of year and antecedent conditions.

Seepage Damage. The seepage damage of concern is that affecting agriculture. Whiskeytown seepage can have both beneficial and detrimental effects. Such water recharges the groundwater body and is sometimes used as a source of water for subirrigation and for leaching agricultural lands, particularly in the Delta. Seepage is also used as a source of water for duck ponds and has other beneficial effects.

In agricultural areas, seepage prevents or delays the use of lands to their full economic potential, delays or prevents planting of crops, reduces crop yields, kills orchards and annual and perennial crops, forces undesirable salts upward into the root zone of crops and trees, and otherwise interferes with farming operations. Seepage also necessitates the construction, operation, and maintenance of drainage facilities on agricultural lands.

The problem of seepage along the Sacramento River occurs during the winter months. Previous studies based on general flow records and related river stage, indicate that no summer seepage damage is occurring along the Sacramento River at present. In some cases, lateral movement of subsurface water from the river during the summer period provides subirrigation to localized areas and crops. No specific data as to the extent of such enhancement are available, however.

Site-Specific Service Areas

The discussion of surface water hydrology and seepage for the regional service area also describes the site-specific service area affected environment.

C-055552

SURFACE WATER QUALITY

Sacramento River Service Area

Introduction

This section describes the surface water quality of the Sacramento River watershed. It focuses on the Sacramento River from Keswick Dam to below the confluence with the Feather River, particularly temperature and constituent concentrations that might be impacted by water contracting. SWRCB water quality objectives for the Sacramento River are identified.

Water Quality of the Sacramento River

For purposes of this water quality description, the river has been divided into three reaches: Reach 1, Keswick Dam to Red Bluff; Reach 2, Red Bluff to Colusa; and Reach 3, Colusa to Verona (below the confluence of the Feather and Sacramento Rivers).

Some general spatial and temporal trends are evident between and within the three reaches. Spatially related trends include the decrease of temperatures in a downstream direction during winter months, and an increase in the same direction in summer months. Also increasing in a downstream direction are concentrations of suspended solids and dissolved solids, turbidity, color, and nutrients. Table 3D-1 summarizes water quality parameters in the lower reaches of the Sacramento River and is presented here to show the general quality of the river water.

Reach 1 (Keswick Dam to Red Bluff). Water quality in this reach is controlled by Shasta Reservoir, which decreases the amount of seasonal temperature variation due to "cold" summer releases and "warm" winter releases. Values for suspended solids, turbidity, and color are the lowest in the river because of Shasta's storage effects. Nutrient concentrations are generally low. Concentrations of metals are a concern because of the high levels in releases from the Spring Creek Debris Dam.

Reach 2 (Red Bluff to Colusa). In this reach, winter river temperatures appear to be fairly constant with a slight downstream decrease. Summer temperatures increase in a downstream direction and are generally higher than in Reach 1. The fluctuations in temperature on an annual basis are also greater here than in Reach 1. Total nutrient concentrations increase in a downstream direction and are higher in the winter.

Reach 3 (Colusa to Verona). Reach 3 is affected by the Feather River and agricultural drainage return flow via the Sutter Bypass and the CBD. The Feather River provides substantial quantities of high quality water to the Sacramento River. The CBD discharges increased quantities of suspended sediments, turbidity, dissolved solids, nutrients, and, at times, pesticides and herbicides. Water temperatures during summer months increase in a downstream direction, while winter temperatures decrease only slightly downstream or are constant. Temperatures generally increase downstream of the CBD discharge confluence and decrease downstream of the Feather River confluence. Reach 3 temperature fluctuations are greater than those in the two upstream reaches.

Rice herbicide concentrations in the Sacramento River, the Sutter Bypass, and the CBD were studied for 1982 and 1983 by DFG (Finlayson and Lew 1982). Sacramento River herbicide concentrations were found to be lower in 1983 than 1982 for two reasons: 1) reduced herbicide concentrations were measured in both agricultural drains (CBD and Sutter Bypass) in that year, and 2) the CBD did not discharge to the Sacramento River in 1983 due to high Sacramento River flows. Throughout the 1982 study, herbicides were not detected in samples collected at the upstream locations of Colusa and Grimes. Generally, concentrations in the Sacramento River increased in a downstream direction, correlating with increased agricultural return flow discharge.

The State of California Department of Health Services set recommended drinking water "action levels" in January 1987. The pesticides that often appear in the Sacramento River are listed here, with their corresponding action levels in parts per billion (ppb): Thiobencarb - 10.0 (tentative); Molinate - 20.0; Bentazon - 8.0; Methyl Parathion - 30.00; and Carbofuran (not listed); Thiobencarb has a taste and odor threshold of 1.0 ppb.

Surface Water Quality Beneficial Uses and Objectives

Water quality objectives for the Sacramento River were established by the SWRCB and RWQCB in the Sacramento River Basin plan. Existing or proposed beneficial uses are listed in Table 3D-2. Objectives for various water quality constituents are shown in Table 3D-3. Most of the water bodies in the Sacramento River watershed are designated for either existing or potential beneficial municipal, irrigation and stock watering, power, recreational contact and noncontact, warm and cold freshwater habitat, cold water fish spawning and wildlife habitat uses. As noted in Table 3C-2, the streams that are not listed there have the same beneficial uses as the streams, lakes, or reservoirs to which they are tributary.

Water Quality of Tributary Inflow

In a 1983 EIS prepared for the Trinity River Basin by the U. S. Fish and Wildlife Service, data collected by DWR and the USGS at Lewiston, Burnt Ranch, and Hoopa were compared with the limits set forth in the State's "Water Quality Control Plan Report for the Klamath River Basin." The comparison indicated that Trinity River water is satisfactory with respect to dissolved oxygen, specific conductance, hydrogen ion concentration, hardness, boron, and most other chemical constituents. However, manganese, iron, and nitrate concentrations slightly exceeded criteria recommended by the SWRCB.

Water temperature has been continuously measured for many years by USGS at the Lewiston gaging station. Since completion of the Trinity Project, temperatures at this location have averaged about 48°F with a range of 43°F-52°F from winter to summer. As the water flows downstream from Lewiston, it is warmed considerably during the summer months. The amount of warming depends on the prevailing weather conditions, the amount

Table 3D-1. Mean Historical Water Quality Parameters in the Sacramento River

Parameters	Concentrations
General Parameters[a]	
Temperature, C	17
Total Dissolved Solids (mg/l)[b]	79
Dissolved Oxygen (mg/l)	10.5
Specific Conductance (10^{-6} mhos/cm)	168
pHO_3)[b]	7.4
Total Alkalinity (mg/l as CaC)	49
Hardness (mg/l) as $CaCo_3$)	62
Nitrogen	
Nitrate (mg/l as N)	0.19
Ammonia and Organic (mg/l as N)	0.33
Total Phosphorus (mg/l as PO_4)	0.42
Dissolved Constituents[b]	
Calcium (mg/l)	8.8
Magnesium (mg/l)	4.3
Sodium (mg/l)	7.0
Sulfate (mg/l)	4.4
Chloride (mg/l)	4.4
Metals[b]	
Iron (10^{-6} g/l)	320
Arsenic (10^{-6} g/l)	<5
Chromium (10^{-6} g/l)	<10
Copper (10^{-6} g/l)	(10)
Manganese (10^{-6} g/l)	(10)
Mercury (10^{-6} g/l)	<1
Zinc (10^{-6} g/l)	<10
Lead (10^{-6} g/l)	<10

Note: Parentheses indicate interpretive approximation of data.

[a] Values represent conditions for the period August 1969 through July 1970 unless otherwise noted. Sampled at Rio Vista (Dewante and Stowell and Brown and Caldwell 1982).

[b] Values represent conditions for the period July through November 1984. Sampled at Sacramento Water Treatment Plant intake (Exhibit 25-A In Support of Testimony on Water Quality and Public Health Considerations Before the State Water Resources Control Board).

C-055556

Table 3D-2. Beneficial Uses in Sacramento Service Area

	Surface Water Bodies[a]	Mun	Agri-culture		Industry			Recreation			Freshwater Habitat[c]		Migration		Spawning		Wild	Nav
		Mun	Agr		Proc	Ind	Pow	Rec 1		Rec 2	Warm	Cold	Migr		Spwn		Wild	Nav
		Mun & Dom Supply	Irrigation	Stock Watering	Process	Service Supply	Power	Contact	Canoeing and Rafting[b]	Other Noncontact	Warm	Cold	Warm[d]	Cold[e]	Warm[d]	Cold[e]	Wildlife Habitat	Navigation
	Sacramento River																	
9	Source to Box Canyon Reservoir		E	E				E		E		E				E		
10	Box Canyon Reservoir							E		E		E				P	E	
11	Box Canyon Dam to Shasta Lake		E	E				E	E	E		E				E	E	
12	Shasta Lake	E	E				E	E		E	E	E			E	E	E	
13	Keswick Dam to Colusa Basin Drain	E	E	E		P	E	E	E	E	E	E	E	E	E	E	E	
14	Whiskeytown Reservoir	E	E	E			E	E		E	E	E			E		E	
15	Clear Creek Below Whiskeytown Reservoir	E	E	E				E	E	E	E	E		E	E	E	E	
16	Cow Creek	P	P	P			E	E	P	E		E		E	E	E	E	
17	Battle Creek		E	E			E	E	E	E	E	E		E	E	E	E	
18	Cottonwood Creek	E	E	E	P	P	P	E	E	E	E	E		E	E	E	E	
19	Antelope Creek	E	E	E				E		E	E	E		E	E	E	E	
20	Mill Creek	E	E	E				E		E	E	E		E	E	E	E	
21	Thomes Creek		E	E			P	E		E	E	E		E	E	E	E	
22	Deer Creek	E	E	E				E	E	E	E	E		E	E	E	E	
23	Big Chico Creek		E	E				E	E	E	E	E		E	E	E	E	
24	Stony Creek		E	E				E	E	E	E	P		E	E	E	E	
25	East Park Reservoir							E		E	E	P			E		E	
26	Black Butte Reservoir		E	E				E		E	E				E		E	
	Butte Creek																	
27	Sources to Chico	E	E	E			E	E			E	E		E	E	E	E	
28	Below Chico, including Butte Slough		E	E				E	E		E	E.		E	E		E	
29	Colusa Basin Drain		E	E				E	E		E	P	E	E	E		E	
30	Colusa Basin Drain to American River	E	E					E	E	E	E	E	E	E		E	E	E
31	Sutter Bypass		E					E			E			E	E	E		
	Feather River																	
32	Lake Almanor						E	E			E	E			E		E	
33	North Fork, Feather River	E					E	E	E	E		E						
	Middle Fork, Feather River																	
34	Source to Little Last Chance Creek		E	E				E	E	E	E	E				E	E	
35	Frenchman Reservoir							E		E	P	E				E	E	
36	Little Last Chance Creek to Lake Oroville	E						E	E	E	E	E				E	E	
37	Lake Davis							E		E	P	E				E	E	
38	Lakes Basin Lakes							E		E		E				E	E	
39	Lake Oroville	E	E				E	E		E	E	E	E	E	E	E	E	
40	Fish Barrier Dam to Sacramento River	E	E					E	E	E	E	E			E	E	E	
	Yuba River																	
41	Sources to Englebright Reservoir	E	E	E			E	E	E	E		E				E	E	
42	Englebright Dam to Feather River		E	E			E	E	E	E	E	E	E	E	E	E	E	
43	Bear River	E	E	E			E	E	E	E	E	E	P	P	P	P	E	
44	American River to Freeport	E	E	E				E	E	E		E	E	E		E		E

Legend: E - Existing Beneficial Uses
P - Potential Beneficial Uses

[a]Those streams not listed have the same beneficial uses as the streams lakes, or reservoirs to which they are tributary.

[b]Shown for streams and rivers only, with the implication that certain flows are required for this beneficial use.

[c]Resident does not include anadromous. Any segments with both COLD and WARM beneficial use designations will be considered COLD water bodies for the application of water quality objectives.

[d]Striped bass, sturgeon, and shad

[e]Salmon and steelhead

Note: Surface waters with the beneficial uses of Groundwater Recharge (GWR), Freshwater Replenishment (FRSH), and Preservation of Rare and Endangered Species (RARE) have not been identified in this plan. Surface waters of Basins 5A, 5B, and 5C falling within these beneficial use categories will be identified in the future as part of the continuous planning process to be conducted by the State Water Resources Control Board.

Source: California State Water Resources Control Board
Water Quality Control Plan Report
Sacramento River Basin, Volume I, 1975

C—055556

Table 3D-3. Water Quality Objectives in Sacramento River Service Area

Objective	Applicable Water Body in Table 3D-2
Turbidity (Jackson Units) and Color	
o No increase beyond natural background levels	9-44[a], D[b]
Bottom Deposits	
o None, other than of natural causes	9-44, D
Floatables, Oil and Grease	
o No visible effects other than of natural causes	9-44, D
Odors	
o None, other than of natural causes	9-44, D
Pesticides[c]	
o No individual pesticides or combination of pesticides shall reach concentrations found to be deleterious to fish or wildlife; no increase in pesticide concentrations over background levels in indigenous aquatic life	9-44
pH	
o No significant change in normal ambient value; shall not be depressed below 6.5 units or raised above 8.5 units as a result of waste discharges, except Goose Lake	9-44, D
Biostimulants	
o No substance will be added which produces aquatic growths in the receiving waters to the extent that such growths cause nuisance or damage to any of the beneficial water uses	9-44, D
Bacteria	
o As recommended by the California State Department of Public Health	9-44, D
Temperature	
o Waters shall remain free from adverse temperature changes resulting from waste discharge or other activities of man	9-44, D
o Heat increases attributed to the activities of man shall be limited as follows: - From December 1 to March 15, the maximum temperature shall be 55°F - From March 16 to April 15, the maximum temperature shall be 60°F - From April 16 to May 15, the maximum temperature shall be 65°F - From May 16 to October 15, the maximum temperature shall be 70°F - From October 16 to November 15, the maximum temperature shall be 65°F - From November 16 to November 30, the maximum temperature shall be 60°F	9, 11
o Shall be maintained at historical levels since 1960 - No heat causing the receiving waters to increase in temperature in excess of 30°F - Normal seasonal and daily temperature variations shall be maintained	9, 11, 13, 30, 44

Table 3D-3. Continued

Objective	Applicable Water Body in Table 3D-3
Temperature, Continued	
o Shall be less than or equal to 75°F or mean daily ambient temperature, whichever is greater, in the epilimnion	10
o Shall be less than 56°F above Hamilton City and less than 68°F below Hamilton City when increases will be detrimental to fishery	13, 30
o Shall conform to State Water Resources Control Board policy	D
Dissolved Oxygen	
o Median shall not fall below 85 percent of saturation in main water mass and the 95 percentile concentration shall not fall below 75 percent of saturation; dissolved oxygen at any location shall not fall below 5 mg/l (7 mg/l in waters above 1,000 feet in elevation) at any time due to waste discharges; when natural factors cause lesser concentrations, then controllable factors shall not cause further reduction.	9-44, D
o Shall be maintained at or near established seasonal levels	13, 30
o Shall be greater than or equal to 9.0 mg/l from Keswick Dam to Hamilton City from June 1 to August 31	13
o Shall be greater than or equal to 7.0 mg/l below Hamilton City from June 1 to August 31	13, 30
o Shall be greater than or equal to 7.0 mg/l all year	40 and Lake Natoma
o Shall be greater than or equal to 8.0 mg/l above Honcut Creek from September 1 to May 31	40
Electrical Conductivity	
o Shall not exceed 230 micromhos (50 percentile) or 235 micromhos (90 percentile) above Colusa Basin Drain or 240 micromhos (50 percentile) or 340 micromhos (90 percentile) at Freeport, based upon previous moving 10 years of record	13, 30, 44
o In well-mixed waters, not to exceed 150 micromhos	33, 36, 40
Trace Constituents or Toxicity	
o No substance which will produce deleterious effects upon beneficial uses shall be discharged to receiving waters	9-44, D
o Shall be maintained below the following levels (in mg/l)[d]	

- Arsenic	0.01	Fluoride	0.5	
Barium	0.1	Iron	0.3	
Boron	0.5	Lead	0.05	13, 30, D
Cadmium	0.01	Manganese	0.05	
Chromium (hexavalent)	0.05	Silver	0.01	
Copper	0.01	Zinc	0.01	
Cyanide	0.01			
- Chlorine	0.01	Mercury	0.005	13, 30
MBAS[e]	0.5			

Table 3D-3. Continued

Objective	Applicable Water Body in Table 3D-3
Prohibitions	
o No waste discharges as specified in policy previously adopted by Central Valley Regional Water Quality Control Board	12, 14, 39, 41, 3[f,g]

[a] "9-44" implies other unnumbered lakes, reservoirs, and streams.

[b] Refers to Sacramento-San Joaquin Delta.

[c] Pesticides are defined as any substance or mixture of substance used to control objectionable insects, weeds, rodents, fungi, or other forms of plant or animal life.

[d] Higher levels are permitted below Keswick Dam under a Memorandum of Understanding signed by Reclamation, DFG, and SWRCB.

[e] Methylene blue active substance (a measure of detergents)

[f] Thermalito forebay and afterbay

[g] Tullock Reservoir

Source: California State Water Resources Control Board
Water Quality Control Plan Report
Sacramento River Basin, Volume 1, 1975

of water released from Lewiston, and the amounts and temperatures of tributary inflows. Larger releases require a longer time and distance to warm up to ambient levels.

Water temperatures in the Sacramento River below Keswick Reservoir are affected by Trinity River diversions, which are at times significantly cooler than waters otherwise released from Keswick. Trinity River flows into the Sacramento basin also contribute to the volume of water available to provide dilution flows for releases from the Spring Creek Debris Dam.

Spring and Flat Creeks. Spring and Flat Creeks contain metal-bearing acid mine drainage from Iron Mountain Mine. The acid mine drainage problems result from groundwater passing through the ore body that was mined from approximately 1960 until 1962. Contaminated water and sediments are retained in Spring Creek Reservoir. Spring Creek Reservoir is operated, in part, to dilute the concentration of metals in releases to nontoxic levels. Releases from the reservoir contain high concentrations of copper, cadmium, and zinc ions which, in lieu of abatement at the source, must be diluted with Shasta and/or Trinity water to keep them at levels to meet Reclamation's 1980 memorandum of understanding with DFG and SWRCB for the Sacramento River below Keswick. Under present CVP operations, problems of maintaining acceptable dilution flows have occurred over the past several years (USDFW 1980).

Clear Creek. Clear Creek, a westside tributary of the Sacramento River, begins in the mountains east of Clair Engle Reservoir, approximately 35 miles from its mouth south of Redding. Whiskeytown Dam and Reservoir stores natural creek flows and water diverted from the Trinity River at Lewiston through the Clear Creek Tunnel. All of the Trinity River water and 87 percent of the natural flows of Clear Creek are diverted through the Spring Creek Tunnel to the Sacramento River above Keswick Dam. The remaining 13 percent is released to Clear Creek (Department of Water Resources 1986). During 1981 and 1982, DWR established 16 water quality monitoring stations from Whiskeytown Reservoir to the Sacramento River. Chemical analysis of the water revealed the presence of several heavy metals, including copper, zinc, and selenium. Summer water temperatures were continuously monitored at a summer flow release rate of 50 cfs from Whiskeytown Dam, where maximum water temperatures occurred during August. Peak water temperatures reached 60°F at Paige Bar, 65°F at Placer Road, 79°F at Little Mill Road, and 82°F at the mouth. These data show that the majority of water warming occurs where the stream exists from a steep, shaded canyon to an open, flat valley terrain.

Whiskeytown Reservoir exhibits a typical temperature distribution with increasing depth. The greatest temperature variations occur during the summer. In August, surface water temperatures reach a maximum of around 75°F, with lower temperatures of 52°F at about 150 feet. Flow releases to Clear Creek from the reservoir can be made from two outlets, one at elevation 972 feet (238 feet deep) and the other at elevation 1,110 feet (100 feet deep). At present, releases are made from both elevations simultaneously to achieve desired temperatures in Clear Creek.

Other Creeks. The water quality of Cottonwood, Big Chico, and Stony Creeks is generally good. These creeks do not transport agricultural return flows and are not believed to contain elevated levels of metals or pesticides; thus, their quality is described in conventional parameters.

Site-Specific Service Areas

Discharges to the SRSA include agricultural return flows, permitted discharges from industrial and municipal sources, urban runoff, and wildlife refuge return flows. These discharges and their water quality are described in more detail in the following paragraphs.

Agricultural Return Flows. Many agricultural drains convey drainage water from irrigated lands within the SRSA to the Sacramento River. Their identification as return flows results from the fact that their source is water diverted from the Sacramento River, although groundwater sources also contribute to irrigation water supplies.

Major drains to the Sacramento River, south of Keswick Reservoir, are:

- Reclamation District 10 drainage,
- Sutter by-pass,
- Reclamation District 108 drainage,
- Reclamation District 787 drainage,
- Reclamation District 1000 drainage,
- Reclamation District 10000 drainage (to Sacramento Slough), and
- Colusa Basin Drain.

The most studied agricultural return flow is the CBD.

Colusa Basin Drain. Water quality data for the CBD were evaluated as part of a 1978 study to assess the water quality impacts of irrigation return water on the Sacramento River. Data were gathered during the 1973, 1974, and 1975 irrigation seasons at stations above, in, and below the drain at Knights Landing. Two stations were placed in the drain in 1973 and 1974, and one in 1975. The temperature range upstream of the CBD was 16.7-18.0°C and the specific conductance range was 140-155 10-6 μmhos/cm in the river, compared to 17.2-20.8°C and 185-450 10 μmhos/cm downstream of the outfall of the CBD.

Other Drains. No evaluation of the water quality associated with discharges from other agricultural drains has yet been identified.

Permitted Discharges from M&I Sources. There are approximately 50 permitted discharges to the Sacramento River and its tributaries within the SRSA. They can be organized into three groups according to their general water quality characteristics: municipal discharges, industrial discharges, and fish hatchery return flows.

Municipal Discharges. Municipal discharges affect each of the water quality constituents identified at the beginning of this section. Approximately 23 municipal wastewater treatment plants discharge to SRSA. The Sacramento Regional Wastewater Treatment Plant (SRWWTP) discharges about 150 mgd and represents more than half of the municipal discharges to the Sacramento River. Effluent limits imposed upon the SRWWTP are the same as those imposed on other municipal discharges.

Industrial Discharges. There are approximately 16 permitted industrial discharges within the SRSA. They include food processing plants, Iron Mountain Mine, lumber and pulp mills, sand and gravel washing operations, and water supply treatment plant filter backwash. Quality of the industrial discharges varies widely. The SRWWTP is likely the largest industrial flow source.

Fish Hatchery Return Flows. Fish hatcheries pump large quantities of water (5-50 mgd) through the facilities to maintain conditions appropriate to support fish growth. The hatcheries treat their effluent to remove suspended solids, and generally meet their effluent quality limit of 5 mg/l. In the past, hatcheries have added formaldehyde to hatchery influents. However, the DFG recently discontinued the use of formaldehyde and is seeking a substitute.

Urban Runoff. Urban runoff from cities and towns within the SRSA is discharged directly to the river or a tributary, or impounded for percolation into an aquifer.

The quality of urban runoff can vary widely, depending on land use, local sanitation and urban runoff quality control practices (for example, use of street sweeping sedimentation basins), watershed topography, rainfall intensity, and antecedent conditions (e.g., time elapsed since previous rainfall, soil moisture).

The quantity of urban runoff generally is not measured, and therefore must be estimated. Key aspects of the water quality associated with urban runoff are summarized below.

Total nitrogen in urban runoff can vary from 1 to 10 mg/l. Ammonium nitrogen can vary from 0-1 mg/l, and nitrate can vary from 0.5 to 5 mg/l.

Petroleum-derived hydrocarbons, known as polynuclear aromatic hydrocarbons (PAH), and toxic metals are typically found in urban runoff. PAH in urban runoff typically vary in concentration from about 10 μg/l to 4000 μg/l (Montoya 1987).

Metals can also adversely affect fish and other aquatic life. Metals in urban runoff are typically found in the following concentration ranges):

Cadmium	0.8 - 10 mg/l
Chromium	0.7 - 20 mg/l
Copper	10 - 150 mg/l
Lead	20 - 1000 mg/l
Mercury	10.1 - 30 mg/l
Zinc	20 - 600 mg/l

A study of urban runoff by the RWQCB was conducted for the city of Sacramento. Based on the study, the mass loadings of urban runoff constituents (copper, lead, and zinc) from the city were as follows:

Mass Loadings (1984-85)

	kg/ac/yr
Copper	0.0174
Lead	0.0482
Zinc	0.144

These values represent the loadings from the entire Sacramento study area, and reflect urban and nonurban regions on a per-acre basis. These values are assumed to represent typical California urban conditions for purposes of comparison (Montoya 1987).

Wildlife Refuge Return Flows. There are five wildlife refuges in the SRSA. The refuges apply water during the fall to attract migrating waterfowl, and stop applying water in the winter when rainfall generally maintains an adequate level. Excess water is returned to the river and tributaries. During the fall, temperatures of the return flow are potentially higher than those of the receiving river water. Because of the evaporation that can occur in the fall, TDS may also become elevated in refuge return flow. The quality of refuge return flow is generally not monitored routinely.

GROUNDWATER HYDROLOGY AND QUALITY

Sacramento River Service Area

Introduction

This section describes the groundwater resources of the SRSA. It focus on existing groundwater development, water table elevations, and groundwater quality because these conditions are important to sustained groundwater use for beneficial purposes. Recent changes and trends in these conditions are also discussed.

Hydrogeology of the Central Valley

The SRSA is located within the Sacramento Valley, which together with the San Joaquin Valley constitutes the Great Central Valley of California. The Central Valley has received sediments from adjoining highlands at least since the Jurassic Period, more than 140 million years ago. As sedimentation continued, the floor of the valley gradually subsided, allowing the accumulation of a vast thickness of sediments without major changes in surface elevation (California Department of Water Resources 1978). Sedimentation has continued to the present, resulting in more than 30,000 vertical feet of sediments in the San Joaquin Valley, and over 50,000 vertical feet in the Sacramento Valley (Page 1986).

Many of these sediments are of marine origin and contain saline water that is not of usable quality. The post-Eocene continental rocks and deposits may contain good quality freshwater and range in thickness from zero at the margins of the Great Valley to over 3,500 feet in the Sacramento Valley (California Department of Water Resources 1978), to a maximum of 15,000 feet at the extreme southern end of the San Joaquin Valley (Page 1986). Even these rocks, however, contain unusable saline water at depth, and it has been estimated that the maximum thickness of freshwater-saturated sediments ranges from about 3,000 feet in the Sacramento Valley (California Department of Water Resources 1978) to 4,700 feet in the southern end of the San Joaquin Valley (Page 1986).

The most important aquifers in the Central Valley are alluvial and reworked volcanic deposits of the Pliocene and Pleistocene Epochs. These include the Tuscan, Mehrten, Tehama, Laguna, and Victor Formations in the Sacramento Valley (California Department of Water Resources 1978), and the San Joaquin, Mehrten, Kern River, Laguna, Tulare, Modesto, Riverbank, and Turlock Lake Formations in the San Joaquin Valley (Page 1986). These formations consist of extremely heterogeneous, poorly sorted mixtures of clay, silt, sand, and gravel, consolidated to various degrees.

The aquifers beneath the San Joaquin Valley are separated in places by widespread, thick, fine-grained layers, deposited as lacustrine and paludal sediments during the Pliocene, Pleistocene, and Holocene Epochs (Page 1986). These layers of silt and clay are effective confining layers, especially in the Tulare Lake bed area, and were responsible for large areas of historic flowing wells in the San Joaquin Valley. There are no corresponding regional confining beds in the Sacramento Valley (Page 1986).

Existing Groundwater Conditions

The SRSA groundwater aquifer is recharged by subsurface lateral inflow from adjacent areas and from surface sources including deep percolation of applied irrigation water and precipitation, and leakage from streams and canals. Groundwater pumping and natural discharge to the Sacramento River and other surface waterways are the principal discharges from the aquifer.

Groundwater flow is controlled by the hydraulic gradient and the transmissivity and storage coefficient of the aquifer. Bloyd (1978) prepared estimates of the transmissivity and storage coefficient of the Sacramento Valley aquifer system using drillers' logs, the results of field aquifer tests, and a digital finite-difference groundwater flow model. He prepared a transmissivity map of the valley showing a range from 4,300 square feet per day to 65,000 square feet per day and a storage coefficient map showing a range from 0.04 to 0.12. Highest transmissivities and storage coefficients are found along the modern river channels of the Sacramento, American, and Feather Rivers.

Modern groundwater pumping and irrigation practices have drastically altered groundwater conditions in the Sacramento Valley. A 1923 USGS Water Supply Paper (summarized by Bloyd 1978) presented a groundwater elevation map for 1912-1913 that differs markedly from present conditions. In 1912-1913, before major groundwater pumping began, the Sacramento Valley groundwater basin was in a state of natural equilibrium. Recharge equaled discharge, and groundwater levels were relatively constant. Depths to water were less than 25 feet in more than 80 percent of the valley (Bloyd 1978), and the Sacramento River was a gaining stream for its entire length (California Department of Water Resources 1978).

The primary recharge areas under natural conditions were along the valley margins, especially in the Stony Creek and Thomes Creek areas in the northwestern part of the valley. The average recharge to the entire Sacramento Valley was approximately 830,000 acre-feet per year. Groundwater flowed from these recharge areas to the river in the center of the valley, and then south to the Delta for eventual discharge to the ocean. The Delta was then also the main discharge area for much of the San Joaquin Valley (Bloyd 1978).

According to a 1978 DWR report, although a 1913 Conservation Commission report stated that the development of irrigation in the Sacramento Valley lagged behind the rest of the state, development of the valley's groundwater and surface-water resources, combined with developing markets for the valley's products, led to a rapid increase in irrigation. In 1920, fewer than 500,000 acres of the Sacramento Valley were under irrigation. This figure increased to 1,000,000 acres by 1950, and 1,500,000 acres by 1970. Groundwater supplied 1.8 million acre-feet, or 29 percent of the irrigation needs of 1970, the rest being supplied by a complex system of surface water reservoirs and canals.

Although water level elevations north of the Sutter Buttes have not changed significantly since 1912-1913, areas south of the Buttes have shown the effects of groundwater pumping. Water level elevations decreased more than 50 feet in a number of areas east of the Sacramento River in Yuba, Placer, and Sacramento Counties between 1912 and 1986, causing major groundwater depressions. These depressions have replaced the Delta as the primary groundwater discharge for the Sacramento Valley, and the Sacramento River is now a losing stream south of the Sutter Buttes. An additional groundwater depression in Solano County south of Davis that was observed in 1961 and 1970 (Bloyd 1978) appears to have completely recovered to natural conditions in 1986 (California Department of Water Resources 1986). A map of elevations of water in wells for Spring 1986 (California Department of Water Resources 1986) is presented in Figure 3E-1.

Sacramento Valley Groundwater Quality

Except for isolated areas with elevated boron levels, groundwater quality in the Sacramento Valley is generally very good. In the mid-1970s, the USGS published a series of three water resources investigations presenting results of major groundwater sampling and analysis projects throughout the Sacramento Valley (Bertoldi 1976; Fogelman 1978, 1979). These studies focused on water quality issues affecting potential M&I and agricultural use of the groundwater resource.

Bicarbonate was the dominant anion in almost all of the groundwater samples analyzed. In most of the samples, there was no dominant cation, although magnesium and calcium were most abundant in all but the southernmost samples, in which sodium was also important. Much of the groundwater in the Sacramento Valley is quite hard, more an aesthetic problem than a health problem for humans or crops. Almost all the groundwater samples analyzed were well below drinking water standards for chloride, fluoride, iron, sulfate, and dissolved solids. None of the wells sampled exceeded drinking water standards for arsenic. A few water samples contained manganese concentrations in excess of the drinking water standard, which was established primarily for aesthetic rather than health reasons. Localized areas of high salinity water (Figure 3E-2) were observed along the Feather River south of Yuba City (Fogelman 1979), along the Sacramento River in the Colusa-Grimes area (Fogelman 1978), and along the aptly named Salt Creek near Williams and a second Salt Creek near College City and Arbuckle (Bertoldi 1976).

Groundwater in the Salt Creek area near Arbuckle may present a boron hazard to irrigators (Figure 3E-3). Although not dangerous to humans, boron in irrigation water can be toxic to certain sensitive crops, including almonds, prunes, and walnuts, all of which are grown in the southern Sacramento Valley. Groundwater adjacent to Salt Creek contains boron in excess of the recommended 0.75 mg/l, but no significant crop damage due to boron had been reported at the time of Bertoldi's (1976) report. In the Yolo-Zamora Water District, some of the groundwater pumped for irrigation contains high (>0.75 mg/l) boron concentrations, presenting potential constraints on the variety of crops that can be grown. The District has requested CVP water in part to selectively retire high boron wells.

A small number of shallow wells throughout the study area, including a cluster of wells near Chico, produced water with potentially hazardous nitrate concentrations (Fogelman 1978). Because high nitrate levels were most often detected in shallow domestic wells, both Bertoldi (1976) and Fogelman (1978, 1979) attributed the elevated nitrate levels to surface contamination of improperly sealed wells.

A separate USGS professional paper was published more recently as part of the Survey's Regional Aquifer System Analysis project (Hull 1984). This paper examined groundwater chemistry in the valley in a more academic manner and attempted to explain some of the chemistry variations noted by Bertoldi and Fogelman as effects of bedrock geology and geochemical processes. Hull shows that much of the chemical variation observed can be explained by differences in the bedrock geology of the nearby mountain ranges; streams draining the igneous rocks of the Sierra Nevada and recharging the east side of the groundwater basin tend to be of better quality than those draining the metamorphic rocks of the Coast Ranges to the west. Hull attributes some of the high-salinity, high-boron groundwater observed in the previous studies to contamination of recharge water by thermal springs in the Coast Ranges, and the areas of high iron and manganese concentrations to reducing conditions within the fine-grained silts and clays found in the midvalley flood basins.

Site-Specific Service Areas

Shasta Dam Area Public Utility District

Groundwater availability is severely restricted in this area making it an unviable supply source.

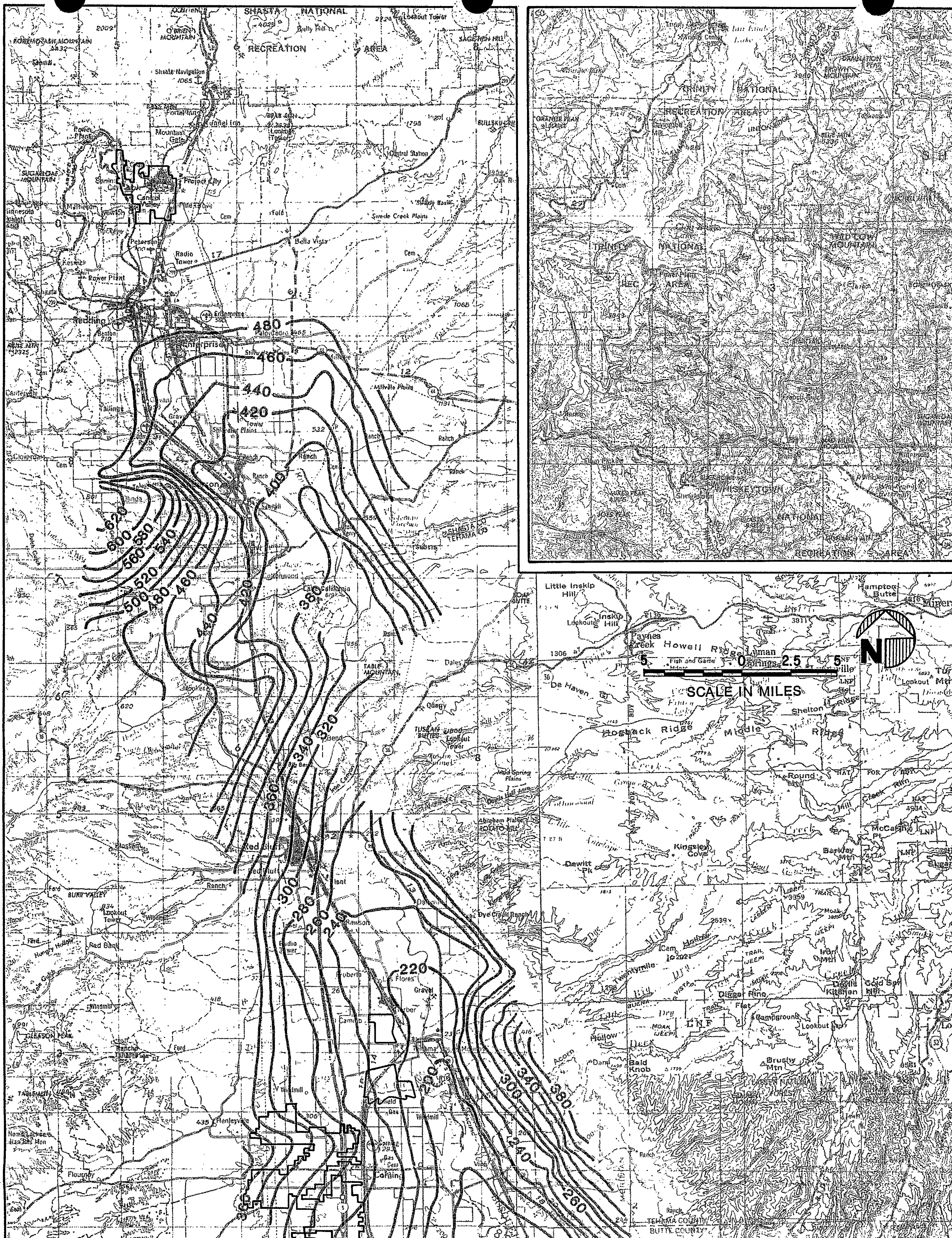
Sacramento Valley Canals Agencies

Hydrogeology. Service areas of these agencies are on the west side of the Sacramento Valley, between the river and the Coast Ranges. The primary aquifer in this area is the Tehama Formation, although shallow alluvial aquifers provide local sources of groundwater.

Groundwater Development. At the present time, the average annual groundwater pumpage is approximately 172,000 acre-feet in these districts. Groundwater currently supplies approximately one-third of the irrigation needs of the districts.

Existing Groundwater Conditions. A spring 1986 DWR groundwater elevation map shows groundwater elevations in these districts ranging from 380 feet in parts of the Corning Water District in the north part of the valley to less than 40 feet in the Dunnigan Water District to the south. Recent trends suggest that groundwater levels are relatively stable.

Groundwater Quality. Groundwater quality in these districts is in general very good, with a total dissolved solids concentration between 200 and 500 mg/l. The typical groundwater north of Colusa is calcium-magnesium bicarbonate in composition, while higher sodium concentrations predominate to the south of Colusa. Isolated zones of high-salinity groundwater near Salt Creek in Williams and Salt Creek near College City are attributable to infiltration of surface water draining marine sediments in the Coast Ranges. Most of the groundwater throughout these areas is either hard (120-180 mg/l as $CaCO_3$) or very hard (greater than 180 mg/l as $CaCO_3$).



LEGEND

120 GROUNDWATER ELEVATION IN FEET ABOVE MSL

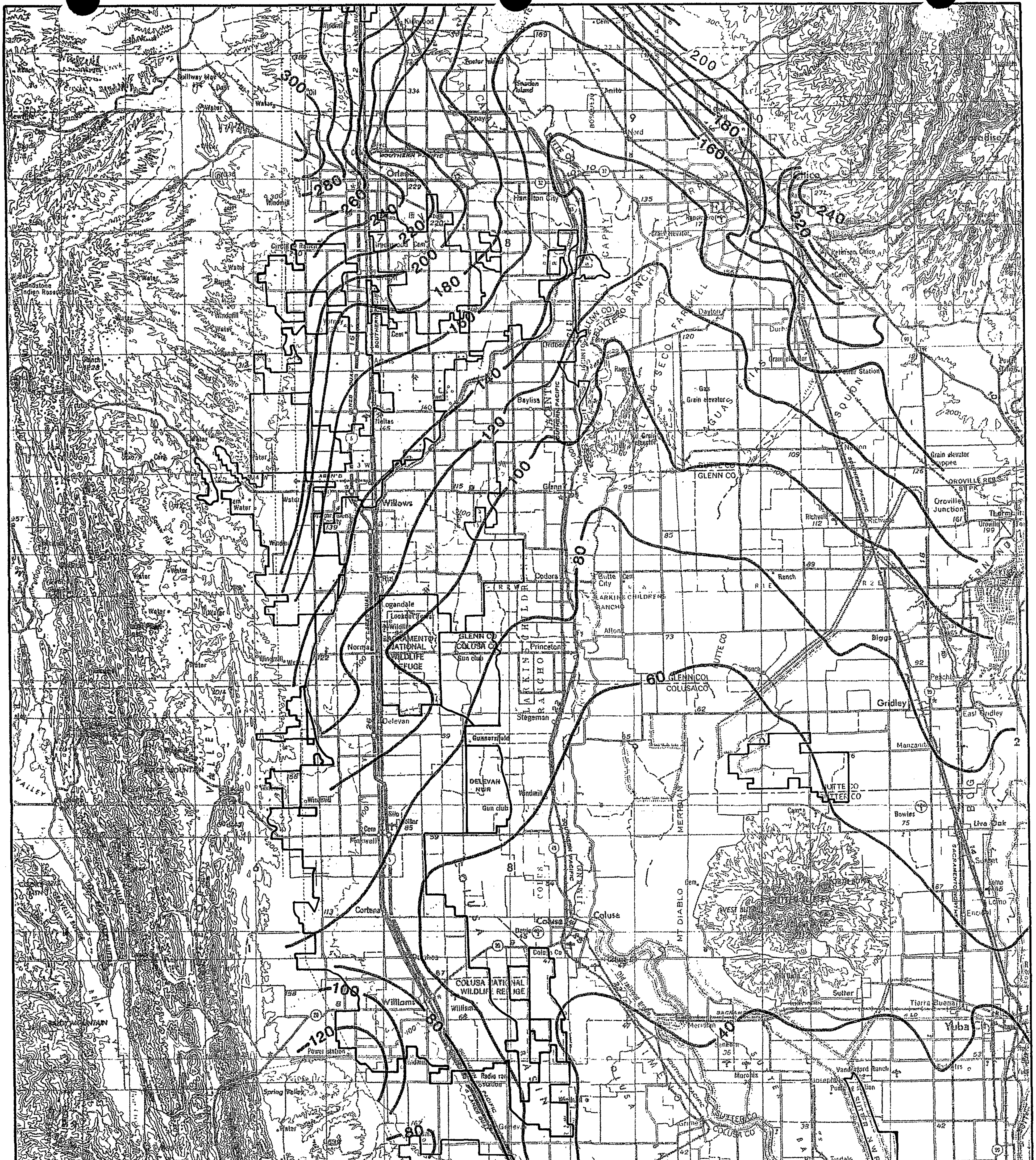
SOURCE: DWR, 1986

FIGURE 3E-1a.

ELEVATION OF GROUNDWATER IN WELLS - SPRING 1986 SACRAMENTO RIVER SERVICE AREA

3E-1

C-055568



LEGEND

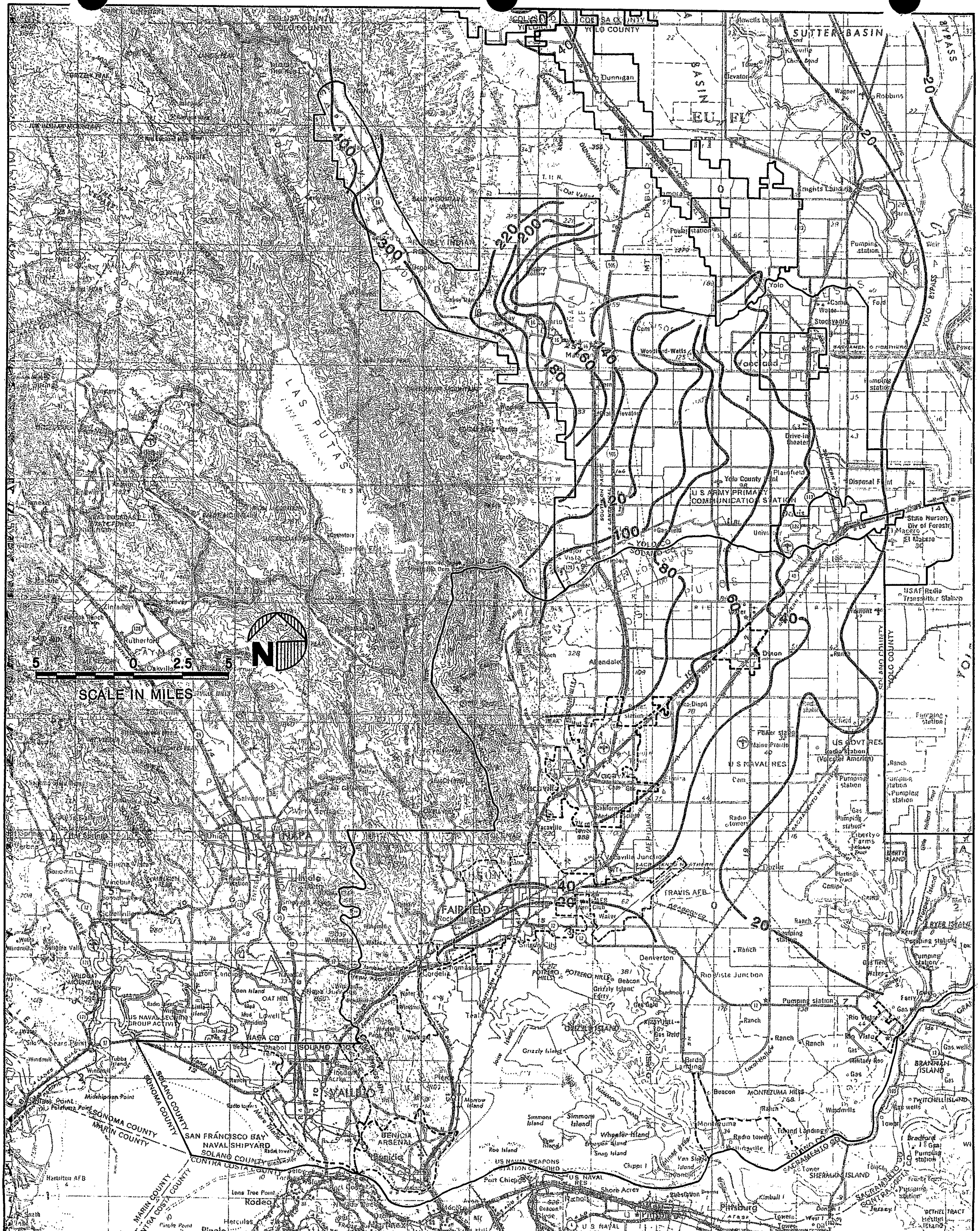
120 GROUNDWATER ELEVATION IN FEET ABOVE MSL

SOURCE: DWR, 1986

FIGURE 3E-1b.

ELEVATION OF GROUNDWATER IN WELLS - SPRING 1986 SACRAMENTO RIVER SERVICE AREA

C-055569



LEGEND

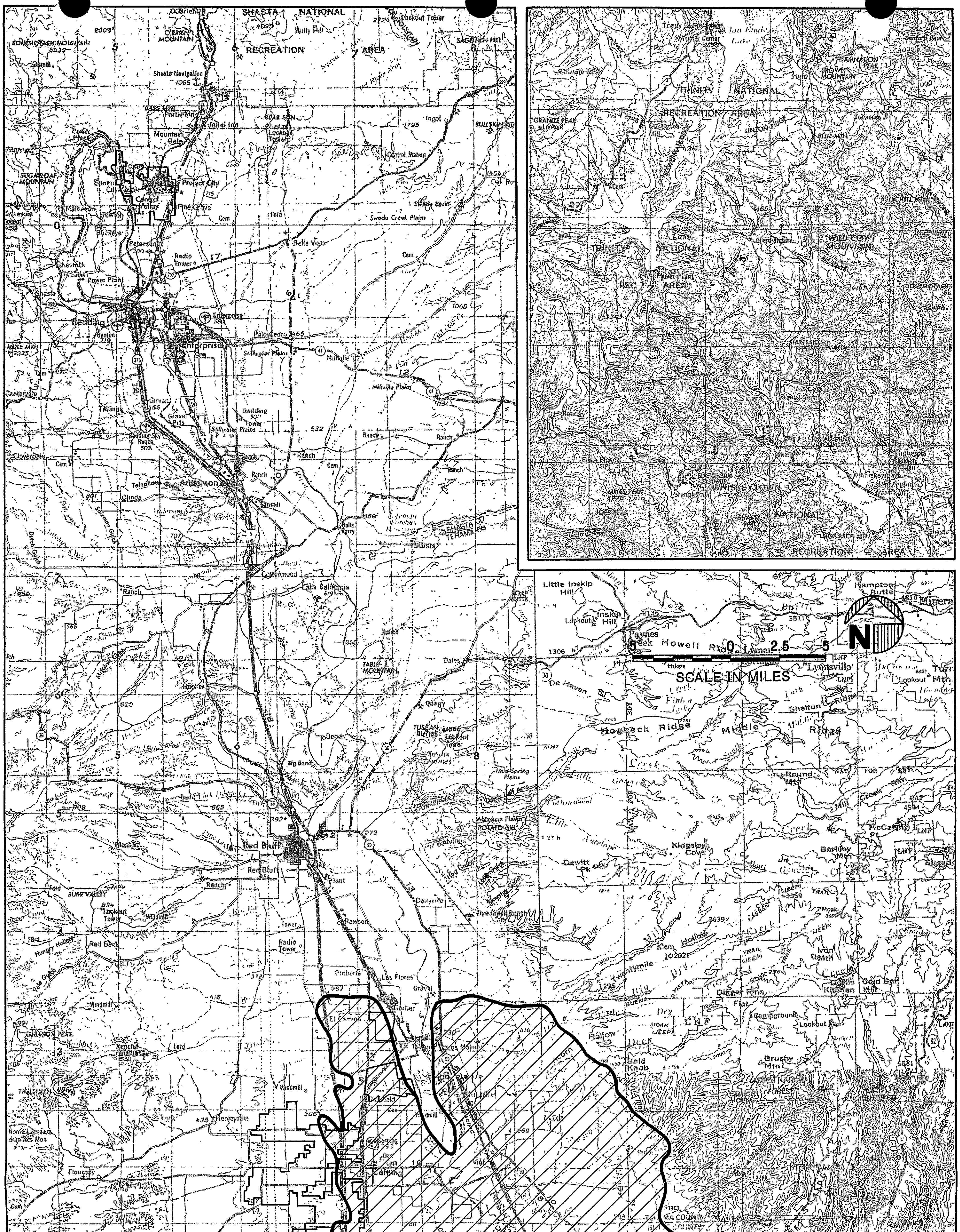
120 GROUNDWATER ELEVATION IN FEET ABOVE MSL

SOURCE: DWR, 1986

FIGURE 3E-1c.

ELEVATION OF GROUNDWATER IN WELLS - SPRING 1986 SACRAMENTO RIVER SERVICE AREA

3E-4



LEGEND

DISSOLVED SOLIDS CONCENTRATION >500 mg/l

DISSOLVED SOLIDS CONCENTRATION <500 mg/l

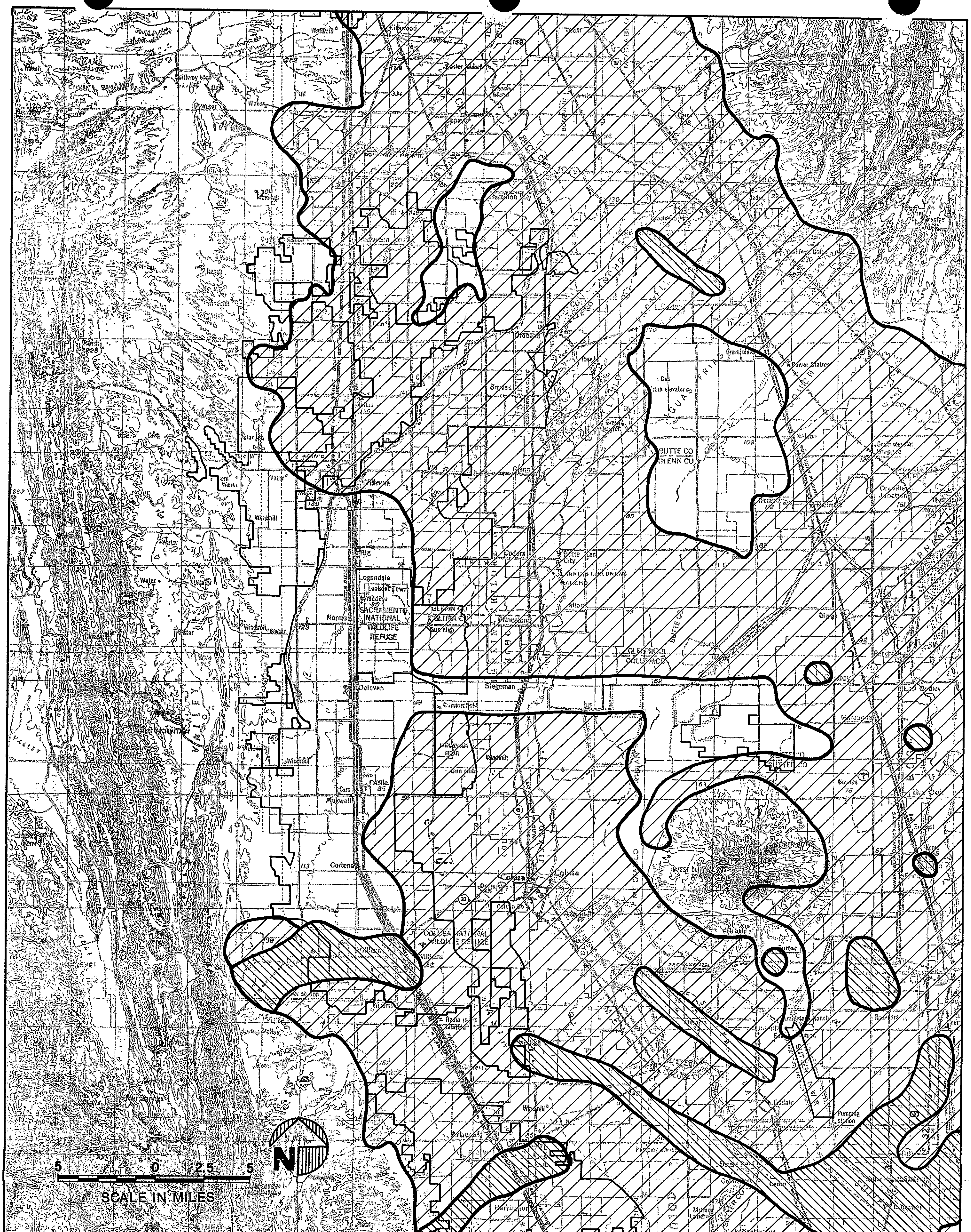
NO DATA AVAILABLE

SOURCES: BERTOLDI, 1976
FOGELMAN, 1978
FOGELMAN, 1979

FIGURE 3E-2a.

GROUNDWATER DISSOLVED SOLIDS CONCENTRATIONS SACRAMENTO RIVER SERVICE AREA

C-055571



LEGEND

DISSOLVED SOLIDS CONCENTRATION >500 mg/l

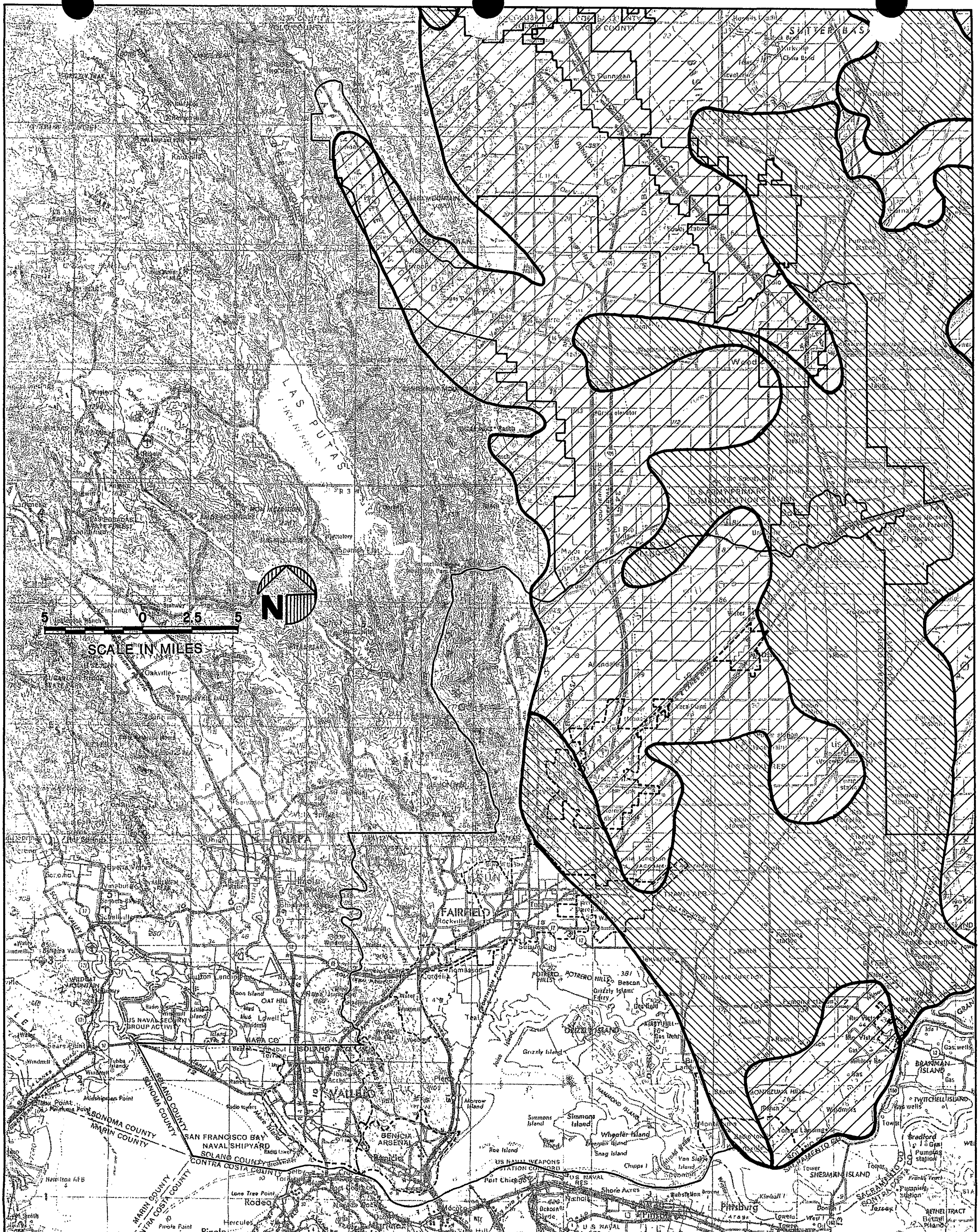
DISSOLVED SOLIDS CONCENTRATION <500 mg/l

NO DATA AVAILABLE

SOURCES: BERTOLDI, 1976
FOGELMAN, 1978
FOGELMAN, 1979

FIGURE 3E-2b.

GROUNDWATER DISSOLVED SOLIDS CONCENTRATIONS SACRAMENTO RIVER SERVICE AREA



LEGEND

DISSOLVED SOLIDS CONCENTRATION >500 mg/l

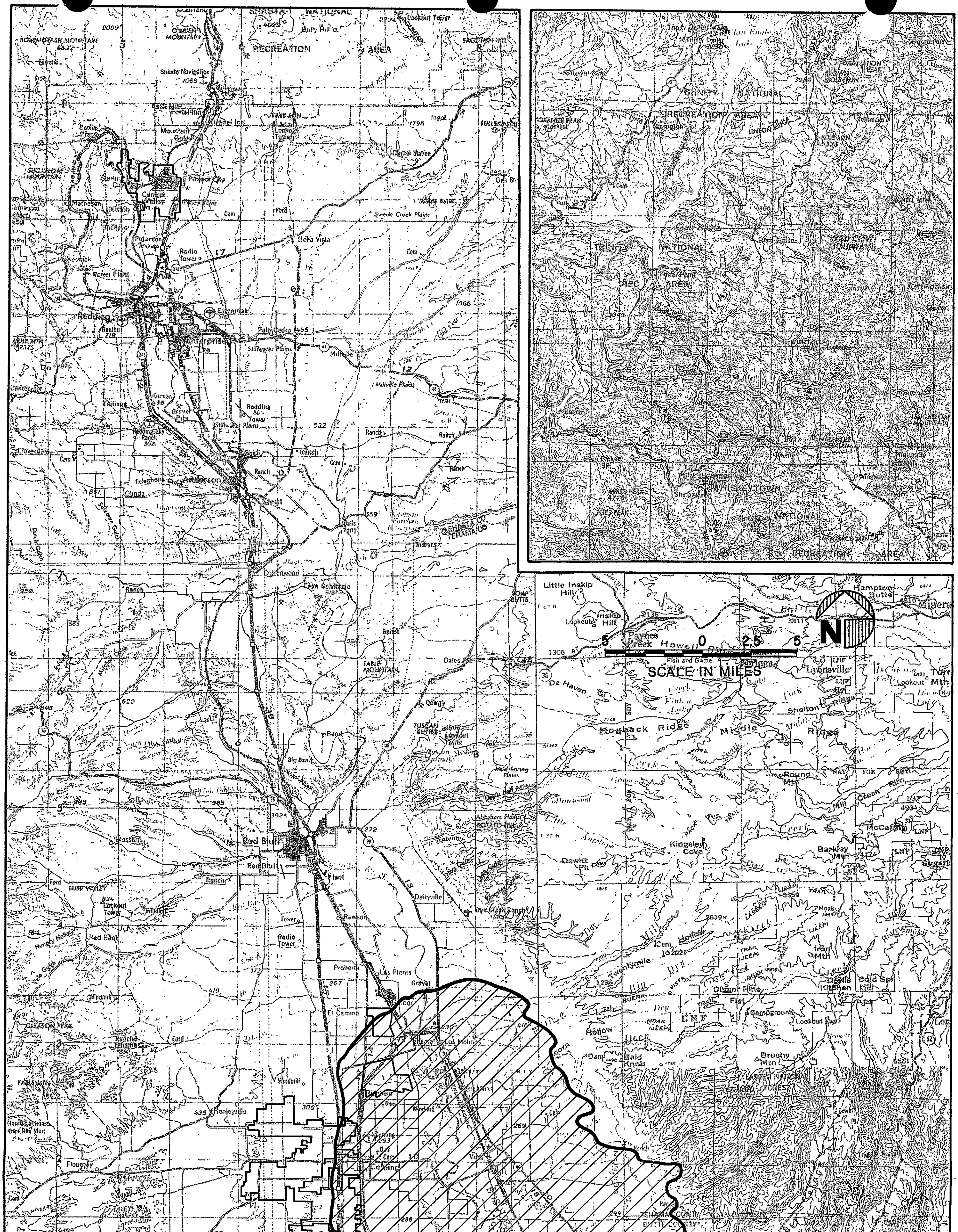
DISSOLVED SOLIDS CONCENTRATION <500 mg/l

NO DATA AVAILABLE

SOURCES: BERTOLDI, 1976
FOGELMAN, 1978
FOGELMAN, 1979

FIGURE 3E-2c.

GROUNDWATER DISSOLVED SOLIDS CONCENTRATIONS SACRAMENTO RIVER SERVICE AREA



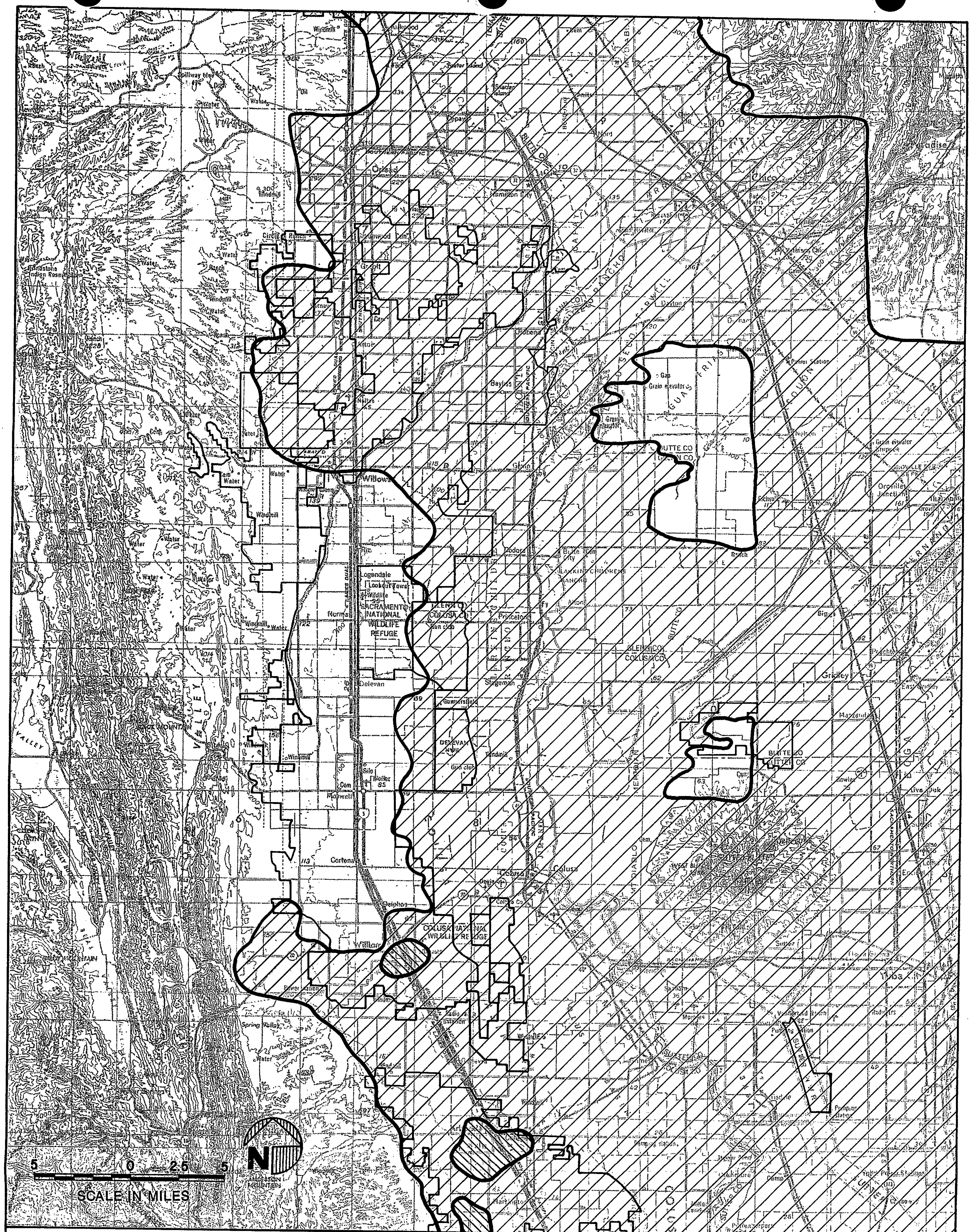
LEGEND

(pattern)	BORON CONCENTRATION >0.75 mg/l
(pattern)	BORON CONCENTRATION <0.75 mg/l
(blank)	NO DATA AVAILABLE

SOURCES: BERTOLDI, 1976
FOGELMAN, 1978
FOGELMAN, 1979

FIGURE 3E-3a.

GROUNDWATER BORON CONCENTRATIONS SACRAMENTO RIVER SERVICE AREA



LEGEND

BORON CONCENTRATION >0.75 mg/l

BORON CONCENTRATION <0.75 mg/l

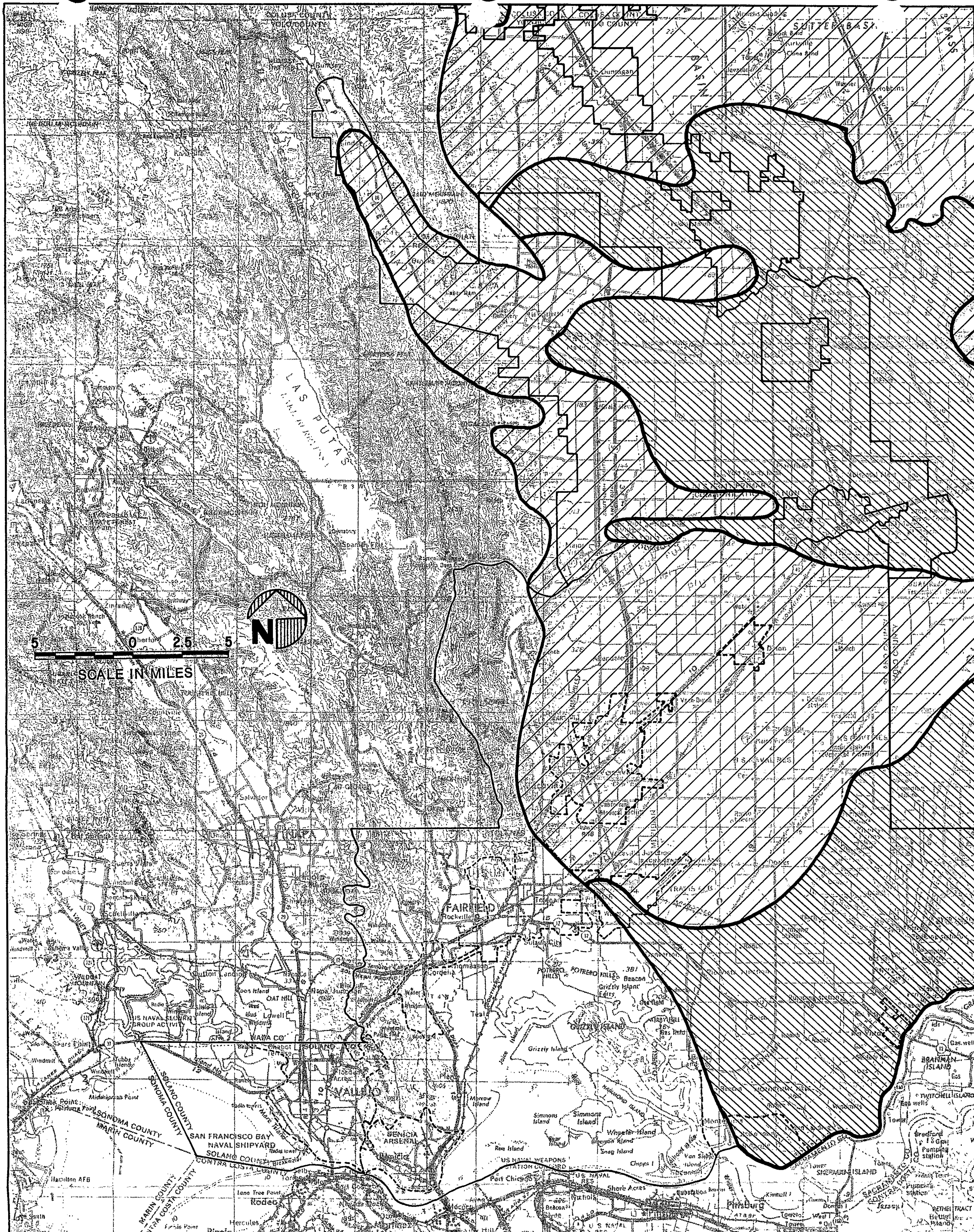
NO DATA AVAILABLE

SOURCES: BERTOLDI, 1976
FOGELMAN, 1978
FOGELMAN, 1979

FIGURE 3E-3b.

GROUNDWATER BORON CONCENTRATIONS SACRAMENTO RIVER SERVICE AREA

3E-4



LEGEND

BORON CONCENTRATION >0.75 mg/l

BORON CONCENTRATION <0.75 mg/l

NO DATA AVAILABLE

SOURCES: BERTOLDI, 1976
FOGELMAN, 1978
FOGELMAN, 1979

FIGURE 3E-3c.
GROUNDWATER BORON CONCENTRATIONS
SACRAMENTO RIVER SERVICE AREA

3-32

C-055576

C-055576

ENERGY

Sacramento River Service Area

The CVP hydropower system is fully integrated into the Northern California Power System and provides a significant portion of the hydroelectric power available for use in northern California. Its nine power plants and two pumping-generating plants have a maximum generating capacity of 1,874,000 megawatts (MW). The major plants are listed in Tables 3F-1 and 3F-2. Power generated by the project is transmitted either by the Western Area Power Administration, a federal agency, or through an agreement with Pacific Gas and Electric Company. Most power produced by the project is used to operate CVP pumping plants or is sold to qualifying public agencies.

Facilities in the SRSA produce a huge net gain in power, with the Shasta Power Plant the largest source in the CVP.

Site-Specific Service Areas

Shasta Dam Area Public Utility District

CVP water is delivered to this district through the Toyon Pipeline, which diverts directly from Shasta Reservoir, bypassing the Shasta Power Plant. Because groundwater availability in the area severely restricted, little energy is used for groundwater pumping at the present time or would be used in the future.

Sacramento Valley Canals Agencies

The Tehama-Colusa Canal is gravity fed from the Red Bluff Diversion Dam. Lands served lie both upslope and downslope from the canal, so pumping is required to deliver water to some of these lands. Typical groundwater pumping lifts for districts in the Sacramento River region are listed in Table 3F-3. In this area, water has been requested primarily for new lands rather than for replacement of groundwater. Corning Water District receives water from the Corning Canal.

Table 3F-1. Major Power Plants in CVP

Unit	Maximum Generating Capacity (kW)	Average Plant Factor (%)
	Sacramento River Service Area	
Carr	145,000	34
Keswick	90,000	62
Shasta	551,000	50
Spring Creek	190,000	42
Trinity	128,000	51
Subtotal	1,105,600	
	American River Service Area	
Folsom	210,000	45
Nimbus	16,000	61
Subtotal	226,000	
	Delta Export and San Joaquin Valley	
New Melones	345,000	26
O'Neill	12,000	1
San Luis[a]	186,670	10
Subtotal	543,670	
TOTAL	1,874,270	

[a] Joint pumping and generating facility, federal share only.

Table 3F-2. Major Pumping Plants in CVP

Unit	Capacity (cfs)	Average Annual Energy Use (kWh)
Sacramento River Service Area		
Corning	500	3,456,000
Glenn-Colusa[a]	3,000	10,584,000
American River Service Area		
Folsom Pumping Plant	350	1,041,000
Delta Export and San Joaquin Valley		
Contra Costa Canal	410	18,908,000
Dos Amigos[b]	13,200	180,146,000[c]
H. O. Banks	10,300	63,339,000
O'Neill	4,200	87,185,000
San Luis	11,000	306,225,000
Tracy	4,600	620,712,000

[a] This energy is not supplied as CVP energy

[b] Joint state-federal facility

[c] Federal energy use

Table 3F-3. Typical Pumping Lifts in the SRSA

District	Typical Lift (ft)
Colusa County Water District	110
Colusa Drain Mutual Water Company	30
Dunnigan Water District	60
Glenn-Colusa Water District	10
Glenn County Lands	30
Glide Water District	20
Holthouse Water District	60
Orland-Artois Water District	40
Rancho Saucus Water District	60
Tehama Ranch Mutual Water Company	30
Yolo Zamora Water District	45

Yolo-Solano CVP Water Service Coordinating Group

New canals or pipelines would have to be built to serve the Yolo-Solano agencies, so it is unclear what pumping would be required. A significant portion of municipal and industrial water supply is pumped from the ground, and CVP water could replace this pumping. The cities of Davis and Woodland rely exclusively on groundwater supplies. A typical pumping lift in Yolo County is 30 feet.

Refuges

Presently, intermittent CVP water is delivered to the refuges by gravity through wheeling arrangements with neighboring irrigation and water districts. Gray Lodge Wildlife Management Area is the only refuge in the SRSA that pumps groundwater. Therefore energy use for groundwater is small.

High boron levels in the southern part of this area, between Arbuckle and Woodland, may limit the use of local groundwater for irrigation of certain boron-sensitive crops. Isolated instances of elevated nitrate levels near Corning suggest surface contamination of individual wells rather than widespread groundwater contamination. There is some evidence of groundwater nitrate contamination in the vicinity of Arbuckle and Knights Landing, possibly due to fertilizer applications. (Bertoldi 1976; Fogelman 1982, 1983)

Yolo-Solano CVP Water Service Coordinating Group

Hydrogeology. Service areas of these agencies are in the southwestern Sacramento Valley, between the river and the Coast Ranges and between Woodland and Vallejo. The primary aquifer is the Tehama Formation, although shallow alluvial aquifers provide local sources of groundwater.

Groundwater Development. At the present time, the average annual groundwater pumpage is approximately 279,000 af in these agencies. Groundwater currently supplies more than half of the irrigation and M&I needs.

Existing Groundwater Conditions. A spring 1986 DWR groundwater elevation map shows groundwater elevations ranging from over 400 feet along Cache Creek in the northwest to less than 20 feet south of Fairfield. Recent trends suggest that groundwater levels may be rising as previous pumping depressions dissipate, particularly in the Dixon and Winters area.

Groundwater Quality. Groundwater quality is quite variable. Bicarbonate is the dominant anion throughout the area, while the relative proportions of sodium, magnesium, and calcium vary across the area. Concentrations of total dissolved solids also vary widely and exceed 500 mg/l in much of the area. Almost all of the groundwater in the area is very hard (hardness in excess of 180 mg/l as $CaCO3$).

A major groundwater quality concern in this area is boron, which at high levels is toxic to many commercially important crops. Groundwater boron levels in excess of 2 mg/l are found north of Davis in the Woodland and Zamora areas, while groundwater boron in much of the area exceeds 0.75 mg/l. No other toxic trace elements occur in troublesome concentrations. (Fogelman 1982, 1983; Evenson 1985)

Refuges

Hydrogeology. There are five wildlife refuges within the SRSA. Three of these (Sacramento, Delevan, and Colusa) are on the west side of the valley, adjacent to Glenn-Colusa and Tehama-Colusa agency lands; the other two (Sutter and Gray Lodge Waterfowl Management Areas) are on the east side of the valley, between the Sacramento River and the northern Sierra Nevada. The primary aquifer on the west side is the Tehama Formation, although shallow alluvial aquifers provide local sources of groundwater. On the east side, the Tuscan Formation may be the most important aquifer.

Groundwater Development. At the present time, only Gray Lodge Waterfowl Management Area meets a significant portion of its need from groundwater. Annual pumpage is estimated to be 5,300 af annually, or about 40 percent of average annual supply. The other refuges have no developed groundwater sources.

Existing Groundwater Conditions. A spring 1986 DWR groundwater elevation map shows groundwater elevations in these refuges ranging from over 120 feet in the Sacramento National Wildlife Refuge to less than 30 in the Sutter National Wildlife Refuge. Recent trends suggest that groundwater levels at the refuges are relatively stable.

Groundwater Quality. Groundwater quality in the refuges is in general very good. Typical groundwater is calcium-magnesium bicarbonate in composition, with less than 500 mg/l total dissolved solids. Neither boron, fluoride, nor other species are present at deleterious levels.

FISHERIES

Sacramento River Service Area

Introduction

This section describes the fishery resources of the SRSA. It focuses on fishery resources of the Sacramento River, particularly chinook salmon. Steelhead trout, American shad, and striped bass are also described because of the economic and recreational importance of these species.

The section also describes fishery resources in Shasta and Clair Engle Reservoirs and in tributary streams that could be affected by individual agency actions as a result of water contracting.

Sacramento River

Physical Characteristics

River Description. The Sacramento River provides more than 300 miles of aquatic habitat for fishes from Keswick Dam to the Delta. Between Keswick Dam River Mile (RM) 302 and the Red Bluff Diversion Dam (RBDD) (RM 243), the river is clear and fast flowing. River geomorphology is controlled by bedrock in this section, as evidenced by the narrow, entrenched channel and low bank erosion rates (Buer et al. 1984). RBDD impounds Lake Red Bluff and slows water velocities upstream for about 3 miles. The predominant streambed material is large rubble and boulders. Gravel deposition areas are relatively scarce except in the vicinity of Redding (RM 300-280).

From RBDD to RM 184, the Sacramento River is a gravel-bed, alluvial river. The river is graded and occupies a wide floodplain belt. Streambed materials consist of sand, gravels, and cobbles, and bank erosion is common. The active erosion and deposition processes create an ever-changing riverine habitat, including gravel bars and backwater areas. Downstream, the Sacramento River becomes larger and slower. Levees control the river channel, and there are fewer gravel areas.

Spawning habitat for salmon has been degraded in much of the Sacramento River by decreases in gravel recruitment rates. Shasta and Keswick Dams preclude recruitment of new gravel from the river and its tributaries above those dams. Gravel mining in tributary streams below the dams also has slowed the recruitment of new gravels into the Sacramento River (California Department of Water Resources 1984).

Hydrology. Sacramento River hydrology has been modified by dams, diversions, and interbasin water transfers. Hydrologic conditions are now controlled largely by Shasta Dam; its afterbay, Keswick Dam; RBDD; and the Trinity River Project. These projects have altered mean monthly discharges, flow duration, and flood peaks and frequency. Shasta Reservoir, with a storage capacity of 4.5 million af, regulates flow from the Pit, McCloud, and Sacramento Rivers. Keswick Dam, located 9 miles downstream of Shasta, has a storage capacity of 23,800 af and provides flow regulation and power generation (U. S. Bureau of Reclamation 1986a). Shasta Dam affects natural flows by:

- o decreasing the minimum discharge,
- o increasing frequencies of very low discharges,
- o increasing frequencies of moderate discharges, and
- o reducing frequencies and volumes of very large flows (U. S. Bureau of Reclamation 1986a).

These effects are reduced with downstream distance because of tributary inflow, primarily from the Feather, Yuba, and American River systems. Additional hydrologic information is provided in "Surface Water Hydrology and Seepage."

Water Quality and Temperature. EPA identified the Sacramento River as one of California's most difficult nonpoint source problem areas, with low-level quality. Major pollution sources include municipal wastes, industrial wastes (primarily from food processing and lumber industries), agricultural drainage, and acid mine wastes (primarily from Spring Creek). Water quality varies spatially and seasonally, attributable largely to the effect of variable streamflows, local waste discharges, and irrigation return flows (U. S. Bureau of Reclamation 1986a).

Water temperature is a critical habitat component for most fish species. Sacramento River chinook salmon are adversely affected by water temperatures that are too warm during the fall months for optimum egg and fry survival and too cold during the spring months for optimum growth. Temperatures also reduce survival in the lower Sacramento River for emigrating salmon fry and juveniles (Mitchell 1987). These temperature conditions are caused primarily by flow modifications. Diurnal temperature flux below the dams, however, has been reduced by controlled, hypolimnetic releases of stored water. Farther downstream, annual and diurnal flux increases in response to atmospheric heating and cooling.

Channel Modifications. Shasta and Keswick Dams preclude salmon and steelhead runs from reaching historic spawning areas. Hydrologic changes from these dams also have modified the Sacramento River channel and substrate composition. Levee and bank protection projects, primarily along the lower Sacramento River, have reduced juvenile chinook salmon rearing habitat, adversely affected gravel recruitment processes, improved habitat for predatory fish such as the Sacramento squawfish, eliminated riparian vegetation and instream cover, and converted much of the Sacramento River into a straight, channelized river.

RBDD and associated facilities also have a major influence on the river. The dam's primary purpose is to allow diversion of water into the Tehama-Colusa and Corning Canals. RBDD has delayed adult salmon migrations up to 40 days because of inadequate attraction flows at the fish ladders and fish disorientation resulting from turbulence downstream of the dam. Delayed juvenile fish passage and predation on disoriented juveniles during

C-055584

emigration are other significant problems. Large Sacramento squawfish below RBDD forage on young salmon passing under the gates. The Anderson-Cottonwood Irrigation District diversion dam upstream from Red Bluff creates similar, but much less severe, problems.

The Tehama-Colusa Canal Fish Facilities (TCCFF) were constructed to mitigate for the construction and operation of RBDD and enhance chinook salmon populations in the Sacramento River. Fish protection features of the TCCFF include fish ladders on either side of RBDD, a louver structure in the Tehama-Colusa Canal headworks (a new positive fish screen is under construction to replace the louvers), and an electric fish barrier in Coyote Creek. Mitigation and enhancement features include two single-purpose channels designed exclusively to provide chinook salmon spawning habitat and a dual-purpose channel designed to convey irrigation water and concurrently provide chinook salmon spawning habitat. Monitoring features of the TCCFF include a system for counting fish climbing the fish ladders at RBDD, a fish trap in one ladder used for collecting biological data on salmon and steelhead runs, a selector facility at the spawning channel terminus for counting and examining adult fish, and a station for collecting and counting juvenile salmon exiting the channel complex (U. S. Bureau of Reclamation 1985a).

The USFWS estimated that the TCCFF could maintain a spawning run of 30,000 chinook salmon: 3,000 as mitigation and the remainder as enhancement. The TCCFF has maintained a mean annual spawning run of about 4,500 fish. The 30,000 fish objective has not been met because of such problems as insufficient flows, aberrant hydraulic characteristics, ineffective fish screens at the Tehama-Colusa Canal headworks, predation from fish, inadequate aquatic algal and weed control, and low juvenile salmon survival. The TCCFF ceased operations in 1988.

Fishery Resources

The Sacramento River currently provides important habitat for a diverse assemblage of fishes, including both anadromous and resident species. Anadromous fish include chinook salmon (four races), steelhead trout, striped bass, American shad, green and white sturgeon, and Pacific lamprey. Resident fish can be separated into warmwater game fish (such as largemouth bass, crappie, catfish, bullhead, and sunfish), coldwater game fish (such as rainbow and brown trout), and nongame fish (such as Sacramento squawfish, Sacramento sucker, and golden shiner). A list of Sacramento River Fishery species and their scientific names is contained in Appendix IV, Table A. Delta-dependent life stages of the species discussed in this section are covered in greater detail in Chapter 5.

Chinook Salmon. The economic value of the commercial and sport harvest of chinook salmon exceeds that of any other fishery in California. Commercial catches of Central Valley chinook salmon have been variable over the last 70 years, but no strong long-term trends are apparent. Peak catches occurred from 1940 to 1960, with present averages approximately 400,000 per year. The ocean sport catch has increased to about 100,000 fish per year while in-river sport catches are about 10,000 annually (Meyer Resources, Inc. 1985). The Sacramento River sustains the largest chinook salmon run in California; over 90 percent of the Central Valley salmon population spawn in the Sacramento River system (Kjelson et al. 1982).

Four runs of chinook salmon--fall, late fall, winter, and spring--occur in the Sacramento River. The fall-run chinook is the most abundant race, comprising about 80 percent of the Sacramento basin stock (Kjelson et al. 1982). The distribution and abundance of each run is limited by the availability of suitable habitat during their respective spawning seasons.

The average spawning stock estimates for fall-run chinook salmon above Red Bluff for 1950-59, 1960-69, and 1970-79 are 190,000, 130,000, and 48,000, respectively (Buer et al. 1984). The average count dropped to 33,000 fish for 1980-85. This value is only 17 percent of the spawning population of the 1950s (Michny and Deibel 1986). Feather and American River runs have increased, however, probably from improved hatchery production (Dettman et al. 1986). Changes in spawning escapements have been accompanied by reductions in the number of large, older fish; in most years, almost 90 percent of the salmon returning to the Sacramento River basin are less than 4 years old with most fish returning as 3-year-olds (Dettman et al. 1986). Stable harvest and declining escapement demonstrate a transition toward greater dependence on hatchery production since the 1960s.

Chinook salmon prefer silt-free gravels, cool temperatures (43.5-57.5°F), and moderate water velocities (1-3 feet per second) for spawning. The onset of spawning typically coincides with a drop in water temperature below 60°F. Eggs are laid in nests dug into the gravel. After about 2 months, the eggs hatch and the alevins remain in the substrate for several weeks before emerging from the gravel as fry.

Suitable spawning conditions are present for fall- and late-fall-run chinook salmon upstream from RM 175 to about RM 300, although spawning gravel quality is reduced with downstream distance from RM 210 (California Department of Water Resources 1984). Fall-run spawning activity typically peaks in November but varies annually depending on water temperatures; higher water temperatures (>60°F) are known to delay fall spawning. Late-fall-run chinook spawn from January through March.

Spawning activity has increased below RBDD since its construction in the mid-1960s and other river modifications. Based on 1980-84 data, about 50 percent of fall-run chinook spawn below RBDD; less than 5 percent of fall-run chinook spawned below RBDD prior to its construction. RBDD is the primary cause of the shift in spawning distribution. The dam is a partial barrier to upstream migrants and contributes to the mortality of downstream migrants through increased predation. Channel armoring and gravel excavation above RBDD are also partially responsible for the shift in spawning distribution.

High water temperature precludes winter- and spring-run chinook salmon from spawning in the lower portions of the Sacramento River (Michny and Deibel 1986); these races successfully spawn only in upper reaches where water temperatures are within acceptable limits. Winter-run fish typically spawn from April to early August while spring-run fish spawn from late-August to early October.

Juvenile chinook salmon habitat preferences have been reviewed by USFWS (Michny and Hampton 1984, Michny and Deibel 1986, Beauchamp et al. 1983). Suitable water velocity, depth, substrate, and cover are important microhabitat components. Each of these conditions, in addition to adequate food supply and water quality, must be present to support juvenile chinook salmon populations (Everest and Chapman 1972, Reiser and Bjornn 1979). Increasing water temperatures in the lower Sacramento River are especially important as they are suspected to be a contributing cause of decline in the natural portion of the basin's chinook salmon run (Dettman and Kelley 1986).

Shallow nearshore habitat is important juvenile chinook rearing habitat. Juveniles are generally associated with velocities and depths in proportion to body size (Chapman and Bjornn 1969); very young chinook prefer low velocities and shallow depths and then shift to faster, deeper water as they grow. Chinook salmon fry also prefer habitats with back eddies, fallen trees, undercut roots, and other protective features (Lister and Genoe 1970). Juvenile salmon are mainly insectivorous and feed largely on drifting organisms.

Juvenile salmon emigration is a complex phenomenon not fully understood. Some fry migrate seaward immediately after emergence while others rear in the river several months before migrating downstream. Rearing and migration activities are not completely separable as they can occur concurrently.

Juvenile salmon released in the Sacramento River at Courtland (RM 34) and Red Bluff (RM 243) resided in the river for an average of 63 and 76 days, respectively (Brown 1986). Migration rates have been found to increase from 5 miles per day in April to 15 miles per day in June (Wickwire and Stevens 1971). Salmon emigration also has been correlated with periods of high discharge and turbidity (Reimers 1973, Davis 1981).

Fry averaging 1.5 inches long dominated both trawl and seine catches within RM 27-70 from January to March (Schaffter 1980). These fish remained inshore and slowly drifted downstream. Smolts (about 3 inches long) dominated catches in April and thereafter, remaining offshore and moving rapidly downstream. The relationship between fish size and downstream migration timing has been reported elsewhere for the lower Sacramento River (Erkkila et al. 1950, Sasaki 1966). Peak emigration through the Delta occurs during the spring, but exact timing can vary from mid-March (Schaffter 1980) to May (Wickwire and Stevens 1971), and even into June (Sasaki 1966). Wickwire and Stevens (1971) found that salmon tended to migrate in the center of the river, typically at night. Visual and hydroacoustic observations indicated that salmon fed actively in the nearshore areas in small schools during the day (BioSonics 1982).

Chinook salmon production in the Sacramento River is dependent on two sources, hatchery and natural production. Although different factors limit the production from each source, the major limiting factors for both are habitat availability, water temperature, and diversions.

The available spawning and rearing habitat is controlled primarily by discharge, although other factors (gravel recruitment, channelization, etc.) exert a major influence. Based on the available information, 6,000 cfs is believed to provide good to optimal spawning and rearing habitat in the upper Sacramento River (U. S. Fish and Wildlife Service 1987a). A major study is nearing completion that will provide detailed information on Chinook salmon habitat needs and availability in relation to discharge levels (Daniel pers. comm.).

Although water temperature is largely dependent on meteorology, impoundment and discharge affects the distribution of cooler waters downstream from Keswick Dam. Storage of cool water (Shasta and Clair Engle Reservoirs) for release during warm periods can increase chinook salmon survival, especially for those spawning during the summer and fall months (U. S. Fish and Wildlife Service 1987). In general, discharge level determines the distance downstream that cool water releases affect temperatures.

Steelhead Trout. Steelhead trout comprise an important recreational fishery within the Sacramento River system. The historic range of steelhead trout in the Central Valley has been reduced considerably by dams that restrict steelhead to the lower portions of major rivers. These areas are generally unsuitable for steelhead spawning and rearing. The reduction in historic spawning and rearing habitats, in conjunction with habitat degradation from many factors, has caused a long-term decline of steelhead populations in the Sacramento River basin although specific basinwide data are lacking. Hatchery production of young steelhead has partially compensated for the loss of naturally spawned fish. Approximately 15 percent of the annual steelhead run in the Sacramento River is the result of stocked fish released as smolts and fingerlings (U. S. Army Corps of Engineers 1985).

Steelhead trout use the Sacramento River as a migration corridor to and from spawning grounds (primarily on tributary streams) and Coleman Fish Hatchery. Steelhead are present in the Sacramento River year-round either as smolts migrating downstream or adults migrating up or downstream. Most spawning fish move upstream in the late fall and winter. Juvenile emigration generally occurs primarily during the spring after 2 or more years of rearing in upstream areas.

Striped Bass. Virtually all of California's American shad and approximately two-thirds of the striped bass spawn in the Sacramento River system (California Department of Fish and Game 1966). The striped bass population of the Sacramento River system has declined from 4 million fish in the 1960s to 1 million fish in 1980 (Cannon 1982), with approximately 55-66 percent of this population spawning in the Sacramento River (California Department of Fish and Game 1972). The annual catch is about 250,000 fish. Both juvenile and adult striped bass abundance has declined over the last 15-20 years, and intensive studies have been conducted to determine the causes. Adult striped bass are found in the Sacramento River primarily during spawning runs from April to June. Most spawning is confined between Isleton (RM 17) and Butte City (RM 169). Semibuoyant eggs and larvae are carried downstream near the bottom and midchannel into the Delta and Suisun Bay. Most eggs hatch between Courtland (RM 34) and Sacramento (RM 60). Larger larvae and juveniles tend to concentrate near the shoreline. During their second year, young bass may move back upstream from the Delta into the Sacramento River.

American Shad. The American shad population has grown tremendously in the last few years, and the adult population is now estimated to be several million (U. S. Fish and Wildlife Service 1976). With the decline of striped bass and other species, the shad fishery has become increasingly popular. Both the striped bass and American shad depend directly on the Sacramento River system and the Delta. Major runs of shad occur up the American, Feather and Yuba Rivers. American shad are similar to striped bass in their use of the Sacramento River. Adult fish are present primarily from April to June during spawning migrations. Spawning occurs in the Sacramento River above Hood (RM

C-055588

38) and in tributaries. Semibuoyant eggs gradually drift downstream before hatching. Some newly hatched shad begin downstream migration immediately, while others remain near spawning areas until they are about 3 inches long. Juvenile shad are common in the Sacramento River from July through November during a protracted outmigration period. Larvae and young juveniles occur in greatest abundance in the Sacramento River from Freeport (RM 46) downstream. Juvenile shad appear to favor the inside of river bends or sandy bars.

White and Green Sturgeon. The adult population of white sturgeon is estimated to be 72,000-212,000 fish (Miller 1972), with an average annual catch of approximately 8,500 fish (Moyle 1976). Green sturgeon population levels are unknown but are believed to be smaller than those of the white sturgeon. Adult sturgeon are found in the Sacramento River from March to June during spawning migrations. White sturgeon are believed to migrate farther upstream than green sturgeon. The adhesive eggs stick to the substrate after fertilization. Larvae stay close to the bottom after hatching and are washed downstream into the estuary.

Other Species. Most warmwater game species prefer quiet, backwater areas and nest on the bottom. These fish seldom inhabit the main channel where current velocities can be high and cover is lacking. Warmwater game species spend their entire life cycle in the Sacramento River and do not undertake spawning migrations. Most species prefer vegetated, shoreline areas. Shaded riverine aquatic habitat provides essential spawning cover for sunfish and channel catfish in particular.

The Sacramento and Trinity Rivers are not known to provide habitat for any federal- or state-listed threatened or endangered aquatic species. Winter-run chinook salmon was recently considered as a candidate for federal-threatened species designation, but the species has been recently rejected for listing twice after reviews by the National Marine Fisheries Service (NMFS). The California Fish and Game Commission also recently declined to declare winter-run chinook salmon as a candidate for state-endangered species status. Nonetheless, winter-run populations remain low, and the race has been placed in Resource Category 1 by the USFWS. The mitigation goal for this category is no loss of existing habitat.

Historically, winter-run chinook salmon populations were probably small and spawned primarily in the McCloud River. Shasta and Keswick Dams blocked access to the McCloud River but created favorable cold-water spawning and incubation conditions in a 44-mile reach of the Sacramento River downstream from Keswick Dam. Completion of RBDD approximately 50 miles downriver from Keswick Dam has severely restricted and delayed migration into the upper river and is considered to be the primary factor impacting winter-run chinook populations. Additional factors identified as harmful to this race include: inadequate river flows, increased predation resulting from human-induced changes in the Sacramento River system, acid-mine drainage, limited gravel supplies, fish entrainment at water diversion structures, and commercial and sport harvest levels. Reclamation has recently agreed with USFWS, DFG, DWR, and COE on a 10-point program to benefit winter-run chinook salmon populations. The central points in the plan are the raising of RBDD gates in winter, additional water releases during the spring and fall, and structural and operational solutions to water temperature problems associated with CVP operations at Shasta Dam (U. S. bureau of Reclamation 1988).

Remnant populations of Sacramento perch, California's only native sunfish, occur in the Sacramento River system. Sacramento perch is currently under consideration as a federally listed threatened species. The species is presently listed as status-undetermined pending collection of additional information (California Department of Fish and Game 1972); base-line resource information on this species is lacking.

Other species of special concern that were historically more abundant in the Sacramento River include hardhead, Delta smelt, and the Sacramento splittail. Spring-run chinook salmon runs have been declining, and this race may be under consideration for special status in the near future.

Sacramento River Tributaries

Several Sacramento River tributaries are located outside of the SRSA, but their anadromous fishery resources are affected by CVP operations on the Sacramento River during either adult spawning migrations or juvenile outmigrations. Smaller tributaries with remnant runs of salmon (presumably fall-run chinook salmon) and steelhead trout include Middle, Sulphur, Stillwater, Bear, Elder, and Thomes Creeks and Secret Ravine. Ash, Churn, Anderson, Salt, and Dye Creeks contain only chinook salmon.

Fall-run chinook salmon are the most numerous salmon and are found in nearly all streams having any salmon run at all. Many streams have only a fall run. The timing of fall runs varies considerably in different valley streams. In general, Sacramento River tributary runs start later than runs in the mainstem Sacramento River. If flows are low, runs do not start upstream in some tributaries until December. The largest runs by far are in the Feather River and Battle Creek, where salmon production from the Feather River Salmon and Steelhead Hatchery and Coleman National Fish Hatchery, respectively, is significant. The Yuba River, a tributary to the Feather River, has a large run of salmon and some steelhead. The Feather and Yuba Rivers have large runs of American shad in most years. Battle Creek is the only tributary known to provide habitat for late-fall-run chinook salmon (Fry and Petrovich 1970).

Spring-run chinook salmon move farther upstream into Sacramento River tributaries than do other salmon runs. They can survive only where there are relatively low summer temperatures. On some valley streams, dams have not only blocked the spring runs, but also raised water temperatures by reducing summer flows. Under these adverse conditions, the spring run has dwindled away in many of these streams to extinction or near extinction. The condition of fall-run fish in these streams may be quite good because the run does not arrive until after the water has begun to cool off. As a result, in the Central Valley, spring-run salmon have become much less numerous than fall-run salmon. Spring-run chinook salmon populations in all of the tributaries are only remnants of historic populations (Fry and Petrovich 1970).

Winter-run chinook salmon presently occur only in the mainstem Sacramento River. Steelhead trout occur in most tributaries containing chinook salmon runs, but steelhead escapement estimates have not been made.

Trinity River

Habitat. Lewiston Dam blocks access to or inundates an estimated 109 miles of anadromous fish habitat. Mainstem Trinity River habitat below Lewiston Dam is used primarily and most importantly by chinook and coho salmon and steelhead trout. The amount of habitat available to the salmon and steelhead trout populations is dependent upon the quantity and quality of river flow releases from Lewiston Reservoir, accretional inflow from tributary streams, and the physical condition of the river channel receiving the releases. Instream flow studies, currently in progress, will provide useful information on habitat-discharge relationships for target anadromous species.

Both the quantity and quality of fish habitat have been significantly diminished. A current estimate places spawning habitat losses at 80-90 percent (U. S. Fish and Wildlife Service 1980). Given declines in salmon and steelhead numbers, overall fish habitat has likely declined by an even larger proportion.

The Trinity River was modeled in 1978 with an instream flow study. This study measured amounts of habitat for adult, spawning, and juvenile rearing chinook salmon in selected representative study areas. The current conditions represent significant reductions in wetted area, spawning habitat, adult holding habitat, and juvenile rearing habitat from historical levels. They also represent increased (adverse) water temperatures at certain times and decreased attraction and downstream transport flows (U. S. Fish and Wildlife Service 1980).

Other factors related to volume of flow and affecting fish habitat in the Trinity River (Lewiston to North Fork) include a number of conditions such as vegetation encroachment, temperature changes, and sedimentation (resulting from human-induced and natural conditions). Studies indicate that the naturally flowing Trinity River once had the capability of transporting all the additional bedload materials that have been contributed by tributaries as the result of land use practices (U. S. Fish and Wildlife Service 1980).

The degraded conditions visually apparent in the Lewiston to North Fork reach include enlarging tributary deltas, shallow pooling of water upstream of deltas, extensive streambed sedimentation, wetted area reductions, channel constriction, steepening banks, encroaching riparian vegetation, reduction in gravel and cobble substrates, and reduced pool depths. Not as readily apparent but equally important are adverse changes in water temperature, benthic insect production, and fish spawning, incubation, and rearing habitat quality. With minor exceptions, existing anadromous fish habitat in the Lewiston to North Fork reach can be considered to be in poor condition.

Reclamation is conducting the Trinity River Basin Comprehensive Action Plan to determine the need for additional flows in the Trinity River. See Chapter 1 for additional detail.

Fish Populations. A variety of resident warm and coldwater fish inhabit many of the lakes and streams of the Trinity River basin. Chinook and coho salmon and steelhead trout use much of the Trinity River basin and are the species of primary social and economic importance. Historically, the Trinity River was known to be an important contributor to the fishery resources of the Klamath River system; the Trinity River was thought to produce one-third to one-half of the salmon. Today, chinook salmon spawn in the mainstem Trinity River, New River, North Fork and South Fork Trinity River and major tributaries. Steelhead trout and coho salmon spawn primarily in tributaries to the Trinity River, although the major portions of the coho runs are believed to be of hatchery origin.

The Trinity River Fish Hatchery was constructed to mitigate the production capacity lost from blockage and inundation of habitat upriver from Lewiston Dam and provides a major component of the existing Trinity River chinook salmon run. Juvenile anadromous fish released from the hatchery depend upon the Trinity and Klamath Rivers for access to the ocean as well as for some rearing. The exact importance of the river for rearing is unknown. Adult fish must also ascend the river to return to the Trinity River Fish Hatchery. The time spent in the river during migrations to and from the ocean may vary from a few weeks to several months. Thus, river flows may directly affect the success of the hatchery in fulfilling its mitigation role.

Overfishing has been advanced as a major factor in the decline of the anadromous fishery. The harvest of salmon spawned in the Trinity River basin takes place primarily in offshore waters, and to a lesser degree in the lower Klamath and Trinity Rivers. The ocean harvest is accomplished by commercial and recreational troll fishermen, the inland commercial and subsistence harvests by Hoopa and Yurok tribes of the Hoopa Valley Indian Reservation, and by sport anglers.

Steelhead trout produced at Trinity River Fish Hatchery or in tributaries to the Trinity River located above the North Fork are harvested by sport fishermen along the Klamath and Trinity Rivers and netted by Native Americans in the lower Trinity and Klamath Rivers. A substantial half-pounder (immature steelhead) fishery historically existed and continues to exist in the lower Klamath and Trinity Rivers.

Reservoirs

The following section is extracted primarily from an extensive assessment of fishery management problems at major Central Valley reservoirs (Leidy and Myers 1984).

CVP reservoirs provide an important component of freshwater angling in California. These reservoirs also have greatly increased warmwater game fish production, although angling in these reservoirs is generally not outstanding. Reservoirs rarely meet the needs of the fish species present, and large, self-sustaining game fish populations are uncommon.

Most CVP reservoirs are managed for multiple uses with water supply and flood control being two of the most important uses. Optimum and even self-sustaining populations of game fish often cannot be achieved simultaneously with water supply and flood control management. These conflicts typically have restricted fish production in reservoirs. Several fishery problems are widespread throughout most reservoirs in the Central Valley.

Extreme water level fluctuation is most frequently noted as adversely affecting fish production. Because reservoirs are used to provide flood control and irrigation water supply, options available to address extreme water level fluctuations are often limited by operating constraints. Water level fluctuations change a number of physical and chemical parameters that impact reservoir populations of bacteria, phytoplankton, zooplankton, macrophytes, and fishes by influencing biomass production, species composition, distribution, and yield. Adverse impacts to spawning sport fishes, such as largemouth bass, occur when water levels increase or decrease in shallow spawning areas during the spawning, incubation, or rearing periods. Declining water levels often eliminate desirable shoreline habitat that provides structural cover for juvenile fishes (e.g., riparian and rooted aquatic vegetation and rocks). Cover habitat is limited in many reservoirs and is often a major problem in itself, without the exacerbating effects of water fluctuations. Other problems include a lack of fishery data and management plans, excessive or under harvest, limited spawning and shallow water habitat, low water fertility, water quality problems, forage fish problems, shoreline erosion, angler access, and the presence of undesirable species.

Primary sport fishery species in CVP reservoirs are largemouth bass, smallmouth bass, and hatchery-reared rainbow trout. Clair Engle Reservoir has provided good angling for kokanee salmon and brown trout as well. Species composition in each Central Valley reservoir varies with the history of species introductions, but some species are now almost universal in their occurrence: largemouth bass, bluegill, carp, golden shiner, black crappie, brown bullhead, mosquitofish, and rainbow trout (hatchery strains) (Moyle 1976).

Site-Specific Service Areas

The discussion below focuses on major conveyance facilities (canals) and Sacramento River tributaries in or affected by water agency or wildlife refuge operations in the SRSA.

Shasta Dam Area Public Utility District

No major conveyance canals or tributaries are associated with this district.

Sacramento Valley Canals Agencies

Most Sacramento Valley water agencies receive water from the Sacramento River via the Tehama-Colusa Canal. Shasta Dam Area Public Utility District receives water from Shasta Reservoir through the Toyon pipeline; Shasta Reservoir fishery resources were previously discussed above. Corning Water District receives Sacramento River water from the Corning Canal, while Glenn-Colusa Irrigation District uses Sacramento River water via the Glenn-Colusa Canal.

Creeks. Sacramento River tributaries in this service area are typically intermittent and contain either no fish or only hardy, warmwater species. Examples of such streams are Bird, Dunnigan, Buckeye, Elk, Walker, Logan, Funks, Corning, Petroleum, Sand, and French Creeks. A few of the larger intermittent tributaries support very small, remnant runs of anadromous salmonids. Thomes Creek supports a fall-run chinook salmon population, while Stony Creek contains fall-run chinook salmon and steelhead trout. Willow, Jewett, Burch, and Oat Creeks may receive occasional stray fish. These streams provide only marginal fisheries habitat.

Canals. At connecting points where bodies of water meet canals, fish migrate or are drawn into canals. In some cases, fish bypass diversion systems designed to keep them out. Some spawning may occur in canals, but population levels are maintained primarily through fish passage. Many fish species do quite well in canals that are not regularly chemically treated or emptied of water. Canals typically contain the same species found in the river being diverted. More tolerant, warmwater species such as black bass, green sunfish, catfish, crappie, carp, Sacramento squawfish, and Sacramento sucker, have better survival rates than salmonids in canals and tend to dominate species composition (U. S. Bureau of Reclamation 1986a).

Although the Corning Canal diversion is unscreened, salmon and other fish losses in the canal are usually small (U. S. Bureau of Reclamation 1986a). Regular chemical treatments and intermittent flows in this canal preclude the establishment of any fish populations. Similar conditions occur at the Glenn-Colusa Canal, which is screened, although many more salmon and other fish enter this canal. One estimate indicates that seven million or more young salmon die at the diversion pumps each year (California Advisory Committee on Salmon and Steelhead Trout 1988), and the screens are completely ineffective under certain conditions (U. S. Bureau of Reclamation 1986a). Adult or juvenile salmon entering either of these canals will perish.

The Tehama-Colusa Canal is the largest canal in the SRSA. Salmon, carp, Sacramento squawfish, Sacramento sucker, and bluegill are the most common species in the canal, although other species in the upper Sacramento River can be diverted. Herbicide treatments in this canal have caused fish kills in the past, and the fishery resources are considered to be relatively poor except for the use of the TCCFF by spawning salmon.

The CBD provides marginal habitat for warmwater species and a few fall-run chinook salmon enter the drain. Poor water quality limits fish production in the drain.

Yolo-Solano CVP Water Service Coordinating Group

Yolo and Solano County water agencies presently receive surface water from Cache Creek, Putah Creek, and the Sacramento River and Delta. Cache and Putah Creeks generally maintain warmwater fisheries composed of largemouth and smallmouth bass, several panfish species, white catfish, black and white crappie, and many nongame fishes. Brown trout are planted in North Fork Cache Creek, while rainbow trout are planted in upper Putah Creek. A few chinook salmon occasionally migrate into Putah Creek during high flows to spawn.

Refuges

Wildlife refuges support populations of largemouth bass, black crappie, catfish, and bullhead. Panfish and carp also are present at Gray Lodge Wildlife Management Area. Unknown numbers of salmon and steelhead enter each of the refuges during high flows but ultimately will die. Young salmon commonly occur in Sutter National Wildlife Refuge, are somewhat less common in Sacramento National Wildlife Refuge, and occur only occasionally in Colusa and Delevan National Wildlife Refuges. Juvenile salmon can also commonly occur in Gray Lodge Wildlife Management Area.

VEGETATION AND WILDLIFE

The vegetation and wildlife resources of the SRSA are described in the following section. Specifically, this section describes the existing habitats, including dominant vegetation, wildlife-habitat relationships, and associated special-status plant and wildlife species.

Sacramento River Service Area

The many plant communities and wildlife habitats within the SRSA can be aggregated into riparian, wetland, terrestrial, and agricultural categories reflecting similar sensitivities to changes in CVP operations and local land uses. Riparian communities depend on habitat conditions along creeks, canals, and rivers. Wetland communities include sites that have inundated or saturated soils on a seasonal or year-round basis. Terrestrial communities occur on upland sites. The scientific names of plant and wildlife species referred to below are included in Appendix V.

Riparian Communities

Riparian communities of the SRSA are found in the bottomlands of the Sacramento Valley and canyons of the north Coast Ranges and Klamath Mountains. Riparian communities are specialized to cope with wide yearly and seasonal fluctuations in flow volumes, an abundance of floodplain moisture, and a dynamic erosion-deposition cycle. Riparian communities share the following features:

- dependency on a relatively constant supply of water in the floodplain aquifer;
- conspicuous zonation parallel to the waterways on gravel bars, and low and high terraces;
- marked contrast and abrupt transitions from riparian to adjacent terrestrial communities; and
- extensive ecotonal edge (i.e., transition between ecosystems) due to the linear distribution of riparian communities, and the interwoven mosaic of various riparian community types.

Riparian vegetation is considered important because of its many resource values. Riparian habitats support a wide diversity of plant and wildlife species whose numbers are disproportionately large relative to the areal extent of the habitat. Riparian areas also support a number of legally protected plant and animal species. Riparian habitat is further enhanced in importance by its current scarcity relative to historic extent and by the threat to remaining stands. Riparian habitats serve humans directly by forming a buffer between rivers and streams, and intensively managed farmlands and urban landscapes, by enhancing water quality through filtration of surface runoff, by stabilizing streambanks, and by moderating flood flows (Murray, Burns, and Kienlen 1978, Brice 1977, Groenveld and Gripentrog 1985).

Riparian habitats typically support a great diversity of wildlife species because they present a unique combination of surface and groundwater, fertile soils, high nutrient availability, and vegetation layering, all of which forms a variety of microclimates (Warner 1979). For example, breeding birds restricted to riparian vegetation (obligates) may outnumber obligates of other habitats as grasslands sevenfold (Tubbs 1980); at least 65 bird species are known to nest in riparian habitats of the Sacramento Valley (Gaines 1974). The linear nature of riparian corridors is another ecological factor responsible for the high species diversity and abundance in these habitats; the "edge effect" of transitions between two habitat zones such as riparian and annual grassland promote greater wildlife diversity than in either habitat alone (Odum 1978). The Sacramento River's riparian corridor is additionally significant because it runs the length of the Sacramento Valley, providing important migratory routes for animals such as birds, deer, bats, reptiles, and amphibians.

Riparian habitats are in a constant successional state because of the dynamic nature of topography and hydrology (Campbell and Green 1968). The resulting successional processes are responsible for the variation in structure (number and relative heights of vegetation layers) and species composition of vegetation types (i.e., communities) in riparian habitats. The interactions between fluvial events, landform type, and the ecological requirements of riparian species must be understood to make clear the processes that control the distribution and vigor of riparian communities (Strahan 1987).

Fluvial processes such as flooding, with its resulting sediment deposition and bank erosion, creates three characteristic riparian landforms: gravel point bars, low terraces, and high terraces. Each landform has a different hydrology because of its physical relationship to the aquifier and flooding. Floods deposit nutrient-rich sediments that contribute to terrace formation by increasing elevations above the floodplain). Floods also pulverize vegetation of gravel bars and low terraces, create anaerobic soil conditions during flood events, erode river banks, and deposit entrained sediment on point bars. The spatial distribution of vegetation is therefore significantly affected by flood intensity, duration, and timing.

Floodplain microtopography is regulated by floods, which create a variety of soil, drainage, and floodplain environments to which plant species have variable tolerances. Tolerance to inundation, flood scour, and lack of soil oxygen regulates the distribution of plants. The seed establishment phase is typically the most sensitive to these events (Strahan 1987).

Point bars and low terraces are most directly influenced by flooding. Species have adapted to these environments and may colonize and live in such habitats. These "pioneer" species disperse their seeds during late spring when flow levels decline under natural conditions; these species require mineral soil for germination and do not germinate or grow in shade. Forests on higher terraces support species that disperse seeds at various times and that can germinate in humus layers under a partial tree canopy. High terrace species are intolerant of long-term inundation and more sensitive to physical damage from flooding.

Riparian communities are grouped into three classes that reflect successional status, and hence location in the floodplain relative to flood flows and elevation above the water table. Gravel bar habitats support pioneer or early successional communities including willow scrub and willow-cottonwood forests. Low terraces support the mid-successional mature cottonwood forests; communities along sloughs and canals such as mixed riparian herb-scrub and willow-alder are included under the low terrace heading because of their similar position relative to the water table. High terraces support the late-successional communities' mixed riparian and valley oak riparian forests.

The riparian communities of mountainous (montane) areas differ because the floodplain is constricted to narrow canyon bottoms, which in turn limit river meandering and the lateral extent of the floodplain aquifer. The extent and composition of montane riparian communities are therefore correspondingly different.

Gravel Bar Riparian. Gravel bar communities tolerate seasonal flooding, although flooding is responsible for pruning and burying newly established vegetation. Gravel bar communities are sensitive to changes in flow volumes, timing, and rates of change in flow volumes. Gravel bar species (i.e., willows and cottonwoods) require coarse mineral substrates that are wetted during seed dispersal (because seeds rapidly lose viability) and during the establishment phase. Therefore, the location of the wetted shoreline zone during late spring and early summer, and its location relative to winter flood flows, are critical factors affecting the location and extent of gravel bar communities.

Vegetation. Two vegetative communities develop on gravel bars: willow scrub and willow-cottonwood forests. Willow scrub vegetation is the "pioneering" vegetation in two topographic locations: point bars and creek edges where dense thickets of one or more willow species (sandbar, red, arroyo, black) develop, and canal slough banks and low river terraces, where dense willow thickets also contain small amounts of cottonwood, white alder, and mulefat, with occasional interior live oak, valley oak, and elderberry along the upper edges. The exotic giant reed and tamarisk are common along some of the intermittent creeks of the north Coast Ranges.

Willow-cottonwood forests form dense sapling stands or forests to 60 feet in height. Black willow, arroyo willow, and cottonwood dominate the canopy. Older stands typically have a midstory of willows and boxelder, or thickets of wild grape, blackberry, and poison-oak. Herbaceous vegetation can be sparse or dense and includes species such as cocklebur, mugwort, umbrella sedge, and horseweed.

Wildlife. The gravel bar riparian community is used by a variety of species that feed on seeds, vegetation, ground-dwelling insects, and vertebrate prey. Species that forage on seeds and foliage in scrub and herb habitats along creeks and rivers include the California ground squirrel, Botta's pocket gopher, California vole, California quail, mourning dove, European starling, American goldfinch, and Brewer's blackbird. Aquatic areas within the river channels also provide foraging habitat for carnivores and omnivores such as river otter, common merganser, common goldeneye, and a variety of gulls.

Ground insectivores of the gravel bar riparian community include the western fence lizard, killdeer, spotted sandpiper, western kingbird, and broad-footed mole. Vertebrate predators include the gopher snake, red-tailed hawk, and striped skunk. Many of these species that use herbaceous habitats are not restricted to riparian systems; they also use natural grasslands and encroach on the disturbed stages of other habitat types.

Unvegetated, vertical banks along the rivers provide nesting substrates for a variety of specially adapted species. The bank swallow, which is particularly dependent on vertical bank nest sites, is discussed in the "Special-Status Species" section below. The belted kingfisher and northern rough-winged swallow are also dependent on vertical banks for nesting, and a few other species such as common barn-owls and burrowing owls will also nest in these habitats.

Because willow scrub habitat frequently grows in dense clumps, it offers cover to a variety of wildlife. Beavers preferentially feed on young willow shoots, and many small birds and mammals feed on willow seeds. Willows support an abundance of insect prey that feed on fresh foliage and stems during the growing season. These insects, in turn, support a high density and diversity of migratory and resident insectivorous birds including the western flycatcher, least Bell's vireo, yellow warbler, MacGillivray's warbler, Wilson's warbler, and song sparrow. Species that have declined or been eliminated from the valley floor as nesting species include the willow flycatcher, yellow warbler, and yellow-breasted chat (Remsen 1978).

Low Terrace Riparian. Low terrace habitats develop as sediment accumulates on gravel bars and serve to elevate them above the floodplain. Communities of this habitat are sensitive to floodplain water level fluctuations, as well as changes in flood intensity or duration. The communities are typically inundated only during flood flows.

Vegetation. Three plant communities develop on low terrace sites: mature cottonwood forest, mixed riparian herb/scrub, and alder willow forests. Mature cottonwood forests develop from young-growth willow-cottonwood forests. Forest heights can exceed 100 feet with a canopy of cottonwood or cottonwood-black willow. Wild grape or mistletoe may also occur in the canopy. A midstory of black willow, boxelder, Oregon ash, and walnut is typical of stands not choked by wild grape, and a dense herb-vine growth often forms an impenetrable understory.

The mixed riparian herb/scrub community is located on riverbanks, berms, and terraces; this vegetation occupies sites where disturbance from levee maintenance and farming practices prevent the development of mature riparian forests. Herbaceous dominants include weedy annual grasses, sedges, rushes, and numerous forbs such as horsetail, mustard, asparagus, and thistle. The scrub layer consists of shrub, vine, and tree saplings of willow, mulefat, blackberry, wild grape, rose, boxelder, cottonwood, and Oregon ash.

Alder-willow forests are primarily associated with canals, sloughs, and channelized rivers where steep gravel, rock, or riprap banks extend to the shoreline defined by sustained summer water levels. Alder-willow forests typically form narrow bands along the shoreline that often overhang the water. The 10- to 40-foot-tall canopy is dominated by white alder, arroyo willow, black willow, and red willow, with some cottonwood and Oregon ash. Higher adjacent ground supports other riparian communities.

Wildlife. The presence of large trees in these forests provides habitat elements required by a number of wildlife species. Cottonwood trees provide adequate nesting support for larger birds such as hawks, owls, American crows, great egrets, and great blue herons. Cavity nesting species such as woodpeckers, wood ducks, bats, western gray squirrels, raccoons, and ringtails require mature stands. Large stands of cottonwood forest offer potential nesting habitat for the yellow-billed cuckoo, a species that has declined dramatically in California in recent decades (Laymon and Halterman 1987).

The mixed riparian scrub community provides a variety of resources used by wildlife. Many plants within this habitat produce fruits that are important to wildlife. Common wildlife species in mixed scrub areas include those dependent on nectar, fruit, and seeds, such as Anna's hummingbird, scrub jay, black-headed grosbeak, lazuli bunting, rufous-sided towhee, house finch, Virginia opossum, raccoon, striped skunk, and gray fox. The mixed scrub habitat also supports many of the insectivorous bird species that occur in willow scrub habitat.

The typically narrow, linear nature of the alder-willow forest favors wildlife that forage in adjacent herbland or agricultural habitats including black-shouldered kites, American kestrels, and western kingbirds. It also provides perches and cover for species that forage in or over the water including double-crested cormorants, green-backed herons, belted kingfishers, violet-green swallows, tree swallows, black phoebes, beavers, river otters, and various bat species.

High Terrace Riparian. High terrace communities are inundated only during peak storm runoff events but are not subject to severe physical battering or erosion (aside from bank erosion), or long-term flooding. The degree of tolerance to a lowering of the summer floodplain water table is unknown.

Vegetation. Mixed riparian forest and valley oak riparian forest typify high terrace riparian communities. Mixed riparian forests develop from mature cottonwood forests as terrace elevations increase and cottonwoods senesce and die, thereby "releasing" midstory trees from the inhibition of overstory shading. This community is characterized by lush, multilayered 150-foot-tall gallery forests. The canopy includes cottonwood, sycamore, Oregon ash, walnut, and valley oak. Midstories include black willow, boxelder, and young trees of canopy species. Shrub understories include often impenetrable vine thickets of wild grape, blackberry, poison-oak, wild rose, and clematis. These vines drape over the midstory and canopy layers, imparting a junglelike appearance. Herb layers are typically dense.

Valley oak riparian forests develop on the highest terraces where flooding is least frequent and short in duration. Valley oak riparian forest develops from mixed riparian forests where dense wild grape vines have not prevented establishment of oak seedlings. The sparse-to-dense canopy consists of valley oak, occasionally interspersed with black walnut. The sparse midstory consists of tree saplings, wild grape, poison-oak, elderberry, and blackberry. A lush grass or sedge-dominated herbaceous layer is typical. Valley oak riparian forests are the rarest community in the Sacramento Valley relative to their original extent. Such rarity stems from the valley oak's position on high terraces, which are attractive sites for urban and agricultural development because of their high soil fertility, high water infiltration rates, and low flood frequency.

Wildlife. Mixed riparian forests support the densest and most diverse wildlife communities in the Sacramento Valley. The diversity of plant species and growth forms provides a variety of foods and microhabitat conditions for wildlife. Many of the mixed riparian plants provide valuable fruits, nuts, or seeds. Wildlife present include most of the species that occur in the cottonwood forest and riparian scrub habitats. The presence of oaks, walnuts, and other mast-producing trees support certain species that do not occur in the previous habitats, such as acorn woodpeckers, plain titmouse, white-breasted nuthatch, and western gray squirrel.

Valley oak riparian forests typically grow some distance from the river channel. The discontinuous canopy allows dense growth of annual grasses in many areas. Oak forests provide nesting sites for large birds that require sturdy nesting sites and an open canopy for easy nest access. Species such as the red-tailed hawk and Swainson's hawk often use the valley oak stands. Herons and egrets may nest colonially in valley oaks. Valley oak stands also provide the best habitat for the acorn woodpecker, plain titmouse, and western gray squirrel. The open oak canopy provides perch sites for aerial foraging species such as the Lewis' woodpecker, ash-throated flycatcher, and western wood-pewee. It also offers perch sites for species that search for prey on the ground, such as the western bluebird and northern flicker. The furrowed bark on older oaks provides foraging habitat for species such as the Nuttall's woodpecker and white-breasted nuthatch that probe and peck for insects. Older trees provide an abundance of holes for cavity-dependent species.

Montane Riparian. Montane riparian community density is associated with flow. Reduced volume or duration of floodwaters can cause in-channel vegetation to increase due to reduced flood scour and sediment movement (Pelzman 1973).

Vegetation. Montane riparian vegetation is confined to a narrow band along the water's edge, and to low terraces and gravel bars within the channel, because of the narrow floodplain. The multilayered vegetation is nearly continuous along the bank, with cottonwood, white alder, and willow sycamore, valley oak, and Oregon ash prevailing as common canopy species. A relatively dense shrub layer of willow, buttonwillow, spice bush, creek dogwood, mulefat, and poison-oak is typical. Because of its proximity to adjacent woodlands and forests, bigleaf maple, flowering dogwood, canyon live oak, Douglas-fir, and incense-cedar are often intermixed.

Wildlife. Narrow bands of montane riparian habitat provide valuable wildlife habitat despite their small areal extent. These areas are typically cooler, moister, and more productive than surrounding habitats. Insectivorous species occurring in these habitats include warbling vireos, Wilson's warblers, yellow warblers, and a variety of shrew species. Herbivores and omnivores that frequent streamside vegetation include rufous-sided towhees, fox sparrows, and western gray squirrels. Black-tailed deer make extensive use of these habitats for fawning, foraging, and escape cover.

Sacramento River Floodplain. The Sacramento River from Shasta Reservoir to the City of Sacramento supports each of the riparian communities identified above. Although much of this vegetation is relatively undisturbed, its extent has been greatly reduced.

C-055601

The DWR (1978) determined that 13,097 acres of riparian vegetation were present from Redding to Colusa. Jones & Stokes Associates (1983) measured 10,360 acres between Red Bluff and Colusa, and the California Reclamation Board (1987) estimated 1,870 acres from Sacramento to Colusa. These estimates indicate that about 15,000 acres of riparian vegetation existed along the Sacramento River during the late 1970s. These estimates do not include tributary streams except for those portions included within the DWR's (1978) "designated floodway."

Trinity River Floodplain Conditions. Montane Riparian communities of the Trinity River are confined to a narrow floodplain by steep canyons and consist of a narrow strip of montane riparian forest and willow scrub vegetation. The vegetation forms dense, near-continuous bands along river edges and some gravel bars. No estimates of areal extent are available.

Clear Creek Floodplain Conditions. The type and extent of riparian vegetation along Clear Creek below Whiskey Town Reservoir varies considerably. This reach includes a degrading channel in mountainous areas that changes to an aggrading channel in the lower reach. Vegetation along the degrading reach consists of montane riparian and willow scrub communities. The aggrading reach supports various riparian scrub and young growth riparian forest communities, including extensive areas of dredger tailings with sparse to dense riparian forest vegetation. No acreage estimates are available.

Wetland Communities

Wetland communities develop in the presence of hydrologic conditions that create seasonal or year-round inundation, or saturated soils. Wetland communities are also characterized by specific vegetation types and nonoxidizing soils.

Wetland communities are important because of their habitat value to dependent plant and wildlife species and current scarcity relative to historic extent. Each wetland community type is adapted to specific hydrologic situations and is therefore sensitive to increases or decreases in water table elevations.

Five wetland communities are recognized in the SRSA: freshwater marsh, alkali meadow, northern claypan vernal pool, northern hardpan vernal pool, and montane meadow.

Freshwater Marsh. Freshwater marshes develop where fine-textured sandy and silty soils are permanently inundated or saturated. The community is intolerant of quickly flowing water, water depths exceeding 5 feet, rapid or wide fluctuations in water level, and salt water. This community is restricted to ponds, canals, sloughs, river backwaters, and similar habitats.

Vegetation. Freshwater marshes in the Sacramento Valley are dominated by dense growths of tules and cattails, with occasional verbena, smartweed, California hibiscus, and various rush and sedge species.

C-055602

Open water in and near freshwater marshes, and along rivers, oxbows, and quiet backwaters, lacks emergent marsh vegetation and is dominated by floating and submerged aquatic species. Common dominants include pondweed, water milfoil, yellow water weed, elodea, duckweed, water fern, bladder wort, water milfoil, horned pondweed, and water lily.

Wildlife. Wetlands within and adjacent to the SRSA provide critical habitat for wintering waterfowl in the Central Valley. These wetlands are recognized as the most important wintering waterfowl habitat in the Pacific Flyway (California Department of Fish and Game 1983, U. S. Fish and Wildlife Service 1986, U. S. Bureau of Reclamation 1986). Approximately 60 percent of the waterfowl that annually use the Pacific Flyway winter in the Central Valley (U. S. Fish and Wildlife Service 1978). For several species, more than 75 percent of the flyway population winters in the Central Valley (Table 3H-1).

Freshwater marshes in the Butte, Colusa, and Sutter basins are key components of California's Central Valley wetlands, which are the highest waterfowl use areas in North America (California Department of Fish and Game 1983). Dabbling ducks make up the majority of the wintering concentrations (Table 3H-1). Key wintering areas for diving species include the San Francisco Bay, Suisun Marsh, and the Colusa Basin. Some nesting by dabbling and diving ducks occurs in the Butte, Colusa, and Sutter basins, and the Delta. The SRSA also offers important wintering habitat for the Canada goose, white-fronted goose, snow goose, Ross's goose, and tundra swan. The Butte, Colusa, and Sutter basins are the key wintering areas for geese, while the Delta marshes are the primary wintering areas for the tundra swan in this region (Bellrose 1980).

Freshwater marshes of SRSA also provide important habitat for a variety of other wildlife species including grebes, herons, egrets, bitterns, coots, shorebirds, rails, hawks, owls, muskrats, raccoons, opossums, and beavers. Many other upland species such as ring-necked pheasants, California quail, black-tailed hares, and desert cottontails take cover and forage at the margins of wetland habitats. Many reptiles and amphibians such as common garter snakes, aquatic garter snakes, Pacific treefrogs, and bullfrogs also breed and feed in freshwater habitats of the region.

Open water portions of ponds, reservoirs, irrigation canals, freshwater marshes, and slow-moving rivers offer habitat for water birds such as pied-billed grebes, American coots, and a variety of waterfowl species. Large bodies of water provide loafing areas for high waterfowl concentrations. Waterfowl and other aquatic birds forage on submerged aquatic plants and associated invertebrates.

Alkali Meadows. Alkali meadows are seasonal wetlands that develop in areas with seasonally saturated alkaline soils. Although historically widespread in the San Joaquin Valley and the Sacramento Valley south of Colusa County, the community is uncommon today due to habitat loss from land conversions.

Vegetation. Alkali meadows are herbaceous communities dominated by low-growing, matted perennials such as salt grass, seepweed, sand sparry, alkali heath, and alkali weed. Common annuals include goldfields, peppergrass, and low barley. Nearly barren scalds encrusted with salt deposits are interspersed. Several special-status plant species are associated with alkali meadows in the project area.

Table 3H-1. Distribution of Pacific Flyway Waterfowl
That Are Dependent on the Central Valley

Species	Average Pacific Flyway Population	Percent of Distribution by Service Area			
		SRSA	ARSA	DESA	Delta/Bay
Snow and Ross' goose	445,510[a]	80	2	13	5
White-fronted goose	69,824	32	2	20	45
Cackling Canada goose	57,744	39	3	38	21
Tundra swan	44,574	23	2	2	73
Cinnamon teal[b]	2,262	18	<1	80	<1
Shoveler	711,797	10	<1	87	2
Wood duck[c]	4,750	99	<1	<1	0
Pintail	3,950,311	57	<1	29	14
American wigeon	807,764	91	<1	9	1
Gadwall	29,117	44	<1	56	<1
Green-wing teal	336,292	44	<1	54	<1
Canvasback	78,229	50	7	3	40
Mallard	1,468,332	77	<1	18	5

[a] Average of 1973-1977 data.
[b] Most cinnamon teal move south to Central and South America.
[c] Numbers underestimated because species prefers dense, woody habitats.

Source: U. S. Fish and Wildlife Service 1978.

Wildlife. Alkali meadow habitats support a similar array of wildlife species that occur in nearby upland sites. When flooded, these meadows attract a variety of waterfowl species and shorebirds. During dry periods, alkali meadows provide habitat for upland bird species such as western meadowlarks, loggerhead shrikes, and numerous small mammal species.

Vernal Pools. Vernal pools develop in shallow basins that form in flat-to-hummocky terrain. Soil durapans underlying the basins prevent water infiltration and the nearly level terrain inhibits surface runoff. Saturated soil conditions cause the water table to become exposed because it is "perched" on the durapan. Hence, surface water accumulates in the basins, forming a seasonal wetland.

Vernal pools are important communities because of their current scarcity relative to historic extent. Holland (1978) estimated that 5-30 percent of California's vernal pools are intact today; the figure for the Central Valley is about 5 percent (Holland pers. comm.).

Vegetation. Vernal pools support an ephemeral flora dominated by terrestrial annual species, with perennial and aquatic species often contributing significant cover. Vernal pool species flower throughout the spring, resulting in conspicuous zonation patterns being formed by consecutively blooming species around drying pool margins. Two vernal pool communities with different floras and soils properties occur in the project area: northern hardpan, and northern claypan vernal pools.

Northern hardpan vernal pools have an iron-silicate durapan and generally acidic soils. Northern hardpan vernal pools are the most common type of vernal pool in California and occur throughout the Sacramento Valley. Characteristic dominants include popcorn flower species, boisduvalia, hairgrass, foxtail, downingia, coyote thistle, goldfields, meadowfoam, owl's clover, pogogyne, woolly marbles, and navarretia.

Northern claypan vernal pools develop on alkaline soils and have a silica-based durapan. Characteristic dominants include popcorn flower species, alkali weed, downingia, Ferris goldfield, mousetail, brass buttons, sand spurry, low barley, and coyote thistle. Northern claypan vernal pools are uncommon in Sacramento Valley, occurring from Colusa County south. They were historically widespread in the Delta and San Joaquin Valley.

Wildlife. Although vernal pools are an ephemeral aquatic habitat, other invertebrates and amphibians also have adapted to this resource. When standing water is available, California tiger salamanders, western spadefoot toads, and Pacific treefrogs may use the pools for egg-laying and for the development of young. Aquatic invertebrates such as clam shrimp, cladocerans, copepods, and crawling water beetles may also inhabit vernal pools. In winter and spring, water birds such as mallards, cinnamon teal, killdeer, California gulls, green-backed herons, great blue herons, and great egrets may use vernal pools for resting and foraging grounds. Western kingbirds, black phoebes, and Say's phoebes feed on flying insects above vernal pools.

Terrestrial Communities

Unaltered uplands throughout the project area support various terrestrial communities that vary in response to elevation, soils, climate, and topography.

Grasslands. Grasslands are the most common community in undisturbed portions of the Sacramento Valley. Although historically widespread, grasslands are relatively uncommon in the Sacramento Valley but are important because of their current scarcity, their value to foraging raptors and other wildlife, and because they support vernal pools and numerous dependent plant and animal species.

Vegetation. Two grassland communities occur in the SRSA, annual grassland and valley needlegrass grassland. Annual grasslands are herbaceous communities dominated by non-native annual grasses with a significant component of native and introduced forbs. Dominant non-natives include brome, oat, barley, fescue grasses, knit grass, filaree species, and cat's ear. Common natives include various popcorn flower species, brodiaea, clover, lupine, poppy, and fiddleneck species.

Historically, valley needlegrass grasslands probably dominated much of the Sacramento Valley (Bartolome and Gemmill 1981). In the Sacramento Valley the community is currently restricted to small scattered sites protected from grazing and other adverse disturbances. Dominant perennial grass species include purple and nodding needlegrass, California melic, pine bluegrass, and blue wild rye. These species intermix with the grass and forb species of the annual grassland community.

Wildlife. Grassland habitats are important foraging areas for many species such as black-shouldered kites, red-tailed hawks, Swainson's hawks, northern harriers, American kestrels, yellow-billed magpies, loggerhead shrikes, savannah sparrows, water pipits, and a variety of swallows. A few birds like killdeer, ring-necked pheasants, western kingbirds, western meadowlarks, and horned larks nest in grassland habitats.

Grassland habitats provide important foraging habitat for raptors, coyotes, badgers, and other predators because they support populations of small mammals such as deer mice, California voles, pocket gophers, California ground squirrels, and black-tailed hares. Common reptiles and amphibians of grassland habitats include gopher snakes, common garter snakes, western toads, and western spadefoot toads.

Ungrazed grasslands with dense cover support a larger number of wildlife species than grazed pastures. However, a few species such as burrowing owls, mourning doves, Brewer's blackbirds, yellow-billed magpies, badgers, and California ground squirrels prefer open pastures.

Blue Oak Woodland. Blue oak woodlands occupy portions of the Sacramento Valley and adjacent foothills. Used primarily for rangeland, fuelwood, and watershed protection, this community is important to many wildlife species.

Vegetation. Tolerant of droughty conditions, blue oak woodlands vary from open savannas to densely stocked woodlands dominated by blue oak, interior live oak, and digger pine. A shrub layer of buckbrush, poison-oak, Parry manzanita, buckeye, and toyon can develop. The herb layer consists of annual or perennial grasslands. Some woodlands in the SRSA may represent live oak woodland due to the dominance of interior live oak.

Wildlife. Blue oaks in the Central Valley and foothills provide shade, shelter, and nesting habitat for many wildlife species. Woodpeckers excavate nest-holes in live and dead trees, and these cavities are subsequently used by other cavity-nesting species such as American kestrels, screech owls, white-breasted nuthatches, and western bluebirds. Oak mast (acorns) is a critical autumn food source for many species such as acorn woodpeckers, valley quail, band-tailed pigeons, northern flickers, scrub jays, western gray squirrels, and black-tailed deer (Verner and Boss 1980). Blue oak foliage and bark attract insects that are important to the diet of birds such as the ash-throated flycatcher, western wood-pewee, plain titmouse, Bewick's wren, Hutton's vireo, warbling vireo, yellow-rumped warbler, black-throated gray warbler, and northern oriole (Beedy and Granholm 1985). Reptiles such as gopher snakes and common garter snakes, and amphibians such as bullfrogs, western toads, and Pacific treefrogs, are likely to occur in blue oak woodland.

Diablan Sage Scrub. This shrub-dominated community occurs on arid, exposed sites in the Coast Range foothills of the San Francisco Bay area, extending north to the Yolo and Solano County region.

Vegetation. Diablan sage scrub vegetation varies from sparse to dense mixed stands of low-growing shrubs such as California sage, California buckwheat, chamise, black sage, snakeweed, bush monkey flower, and silver bush lupine. The herb understory is a species-rich, sometimes lush annual grassland.

Wildlife. Arid shrublands of the foothills offer shade, shelter, and food to birds and other wildlife. Typical species include common poorwills, wrentits, California thrashers, rufous-sided towhees, brown towhees, Anna's hummingbirds, black-chinned hummingbirds, blue-gray gnatcatchers, sage sparrows, and rufous-crowned sparrows. Both resident and migratory black-tailed deer rely on chaparral. Other mammals commonly found in chaparral include the Sonoma chipmunk, coyote, and bobcat. Common reptiles include the western fence lizard, western rattlesnake, and common kingsnake.

Agricultural

Vegetation. Agricultural habitats are common throughout the SRSA and include a variety of different types including seasonally flooded, irrigated, and dryland.

Wildlife. Large portions of the SRSA are used for agricultural production. Though highly modified from natural conditions, rice fields provide very productive habitat for waterfowl, shorebirds, and other wildlife. Flooded rice fields function as seasonal wetlands to provide an important supplement to natural marshlands. Fields also attract great egrets, American bitterns, northern harriers, black-necked stilts, American avocets, and other wading birds.

Croplands and pasturelands are also of value to wildlife. Grazed pasturelands provide habitat for grassland animals like turkey vultures, red-tailed hawks, black-shouldered kites, burrowing owls, mourning doves, ring-necked pheasants, western kingbirds, loggerhead shrikes, California ground squirrels, black-tailed hares, and coyotes. Corn, wheat, and other grains provide food and nest sites for waterfowl, pheasants, and various small birds and mammals. Row crops and orchards have the least value as wildlife habitat but do provide food and cover for some bird and mammal species.

Special-Status Species

For purposes of this report, special-status plants are defined to include:

- o State of California rare, threatened, or endangered species (DFG 1986);
- o federally listed, proposed, or candidate threatened or endangered species (50 FR 39526-39584, Sept. 27, 1985); and
- o California Native Plant Society (CNPS) rare and endangered species (Smith and York 1984).

For purposes of this report, special-status wildlife species are defined to include:

- o federally listed, proposed, and candidate threatened and endangered species (50 FR 37958-37967; September 18, 1985); and
- o California listed and candidate threatened and endangered species (California Department of Fish and Game 1987a).

Two criteria were used to develop a list of special-status species that could potentially be affected by water contracting: listed, proposed, or candidate species with known populations in or near the project area; and species that can occur in the types of habitats and communities present in the SRSA. The following sources were used in developing this list: DFG's Natural Diversity Data Base (NDDB) (1987), Smith and Berg (1988), a Section 7 (ESA) consultation letter (Harlow pers. comm.), California Native Plant Society (CNPS) (1985) EDAW and Wesco (1981), DFG/USFWS (1980), DFG (1975), Hoover (1935), and file information of Jones & Stokes Associates.

The NDDB record search and subsequent analysis showed that 28 special-status plants and 25 special-status wildlife species could potentially occur in the SRSA. The potential species are listed in Appendix V, Tables B and C, where their legal status, geographic range, and habitat associations are indicated.

Site-Specific Service Areas

Shasta Dam Area Public Utility District

Biological Communities. Riparian (including forested and nonforested types), wetland, grassland, and blue oak woodland habitats are known to occur in the Shasta Dam

Public Utility District (Appendix V, Table D). In addition, northern hardpan vernal pools could occur in the district in areas with relatively level topography and untilled grasslands or blue oak woodlands.

Special-Status Plant Species. Ten special-status plants could occur within this agency, because suitable habitat exists within the documented geographic range of the subject species (Appendix V, Table E). No extant populations are reported by NDDB (1987).

Special-Status Wildlife Species. Ten special-status wildlife species could occur or occasionally use undisturbed habitats in the agency because habitat is suitable and is within the documented geographic range of the subject species (Appendix V, Table F). No special-status wildlife have been reported from the agency (NDDB 1987).

Sacramento Valley Canals Agencies

Biological Communities. All 11 requesting agencies in this group contain riparian habitats, including seven with forested riparian communities. All but the Rancho Saucus Water District have wetland communities based on the USFWS National Wetland Inventory maps (various dates); all agencies could contain vernal pools communities because of the presence of untilled grasslands with relatively level topography; and alkali meadows have the potential to occur in seven of the requesting agencies, considering the presence of untilled habitats with seasonal wetland hydrologies (Appendix V, Table D). Undisturbed grasslands and blue oak woodlands were documented in 11 and five of the requesting agencies, respectively.

Special-Status Plant Species. An occurrence of the caper-fruited tropidocarpum on Glenn County lands represents the only special-status plant species previously reported from these agencies. Each of the requesting agencies could contain one or more of 24 special-status plant species based on the presence of Suitable habitat and because of the agencies' locations within the documented geographic range of these species (Appendix V, Table E).

Special-Status Wildlife Species. The valley elderberry longhorn beetle, tricolored blackbird, Swainson's hawk, and bank swallow have previously been reported from the Glenn-Colusa Irrigation District and/or Glenn County lands (Appendix V, Table F). Each of the requesting agencies could contain one or more of 13 special-status wildlife species based on the presence of suitable habitat.

Yolo-Solano CVP Water Service Coordinating Group

Biological Communities. Of the 11 requesting agencies within the Yolo-Solano CVP Water Service Coordinating Group all have riparian (with five containing forested riparian), wetland, and grassland habitats. Blue oak woodlands occur in six of the agencies. Northern claypan vernal pools and alkali meadows could occur in each of the agencies because of the presence of untilled grasslands with seasonal wetland hydrology (Appendix V, Table D).

Special-Status Plant Species. The Suisun marsh aster, California hibiscus, Contra Costa goldfield, delta tule pea, and caper-fruited tropidocarpum have been reported from three requesting agencies. Each of the requesting agencies could contain one or more of 24 special-status plants based on the presence of suitable habitat (Appendix V, Table E).

Special-Status Wildlife Species. The Sacramento anthecid beetle, California clapper rail, Swainson's hawk, California black rail, white-faced ibis, mountain plover, long-billed curlew, tricolored blackbird and the salt marsh harvest mouse have previously been reported from eight of the requesting agencies in this group. Each of the requesting agencies could contain one or more of 22 special-status wildlife species based on the presence of suitable habitat (Appendix V, Table F).

Refuges

Biological Communities. Refuges in the SRSA are significant because they support vestiges of natural habitats once common throughout the Central Valley. Of considerable importance are the presence of seasonal alkaline wetlands (vernal pools, alkali meadows, alkaline marsh) that once were widespread throughout the Central Valley but now are restricted to isolated remnants in areas not converted for urban or agricultural uses.

All refuges in the SRSA support woody (i.e., forested) and herbaceous riparian communities. Each refuge supports a variety of wetland communities, and with the exception of the Sutter National Wildlife Refuge, all support northern claypan vernal pools and alkali meadows. Each refuge also supports seasonally flooded wetlands, permanent ponds, and agricultural fields developed for wildlife habitat, primarily waterfowl, and each has various acreages of undeveloped "uplands" (Appendix V, Table G). Vernal pools and alkali meadows generally occur in habitats the USFWS designates as uplands, although these communities also exist in cells that are currently under active use, or that are not under current active management.

Special-Status Plant Species. Heartscale, brittlescale, palmate-bracted birds beak, and California hibiscus have previously been reported from refuges in the SRSA. Each of the refuges could contain one or more of 15 special-status plants, based on their habitat associations and distributions (Appendix V, Table H).

Special-Status Wildlife Species. The giant garter snake, bald eagle, American peregrine falcon, Aleutian Canada goose, Swainson's hawk, white-faced ibis, greater sandhill crane, long-billed curlew, and tricolored blackbird have previously been reported from one or more refuges. Up to 12 special-status wildlife species could occur on each refuge based on the habitat types present at each (Appendix V, Table I).

RECREATION

Sacramento River Service Area

Introduction

The availability of adequate water supplies is essential to meeting the demands for recreation at reservoirs, lakes, and rivers in California. Certain activities, such as swimming, boating, and fishing, are dependent on water resources, whereas other activities, such as hiking, sightseeing, and nature appreciation, are enhanced by water.

This section describes the recreational resources of the Sacramento River, and Shasta and Clair Engle Reservoirs including the most common types of recreational activities and numbers of user days.

Recreation travel patterns in California indicate that considerable interregional travel occurs in pursuit of water-based recreation opportunities. In this context, recreation areas located throughout the state provide substitute opportunities for recreation areas within a region.

From the recreationist's perspective, the selection of a particular area for recreation depends not only on the access costs and attributes of that area, but also on the costs and attributes of all recreation areas that serve as alternatives. Site attributes include the size of the recreation area, accessibility, facilities available, fish and wildlife resources, and aesthetic qualities.

Recreation areas adjacent to highways are generally in greater demand than sites requiring several miles of hiking for access. Developed facilities enhance site attractiveness and increase user capacity for most activities. Important facilities include boat ramps, marina slips, parking spaces, campsites, picnic sites, and trails.

Hunting and fishing are dependent on wildlife and fish resources. Other activities (e.g, sightseeing) are enhanced by them. Wildlife and fish resources reflect the likelihood of hunting or fishing success and species diversity, both of which are expected to enhance recreation demand.

Recreation and leisure are important aspects of modern life. Recreational activities contribute significantly to the personal welfare and quality of life of most citizens. Increasing proportions of the national income are being devoted to the planning and spending of leisure and recreational time and to provision of related facilities and services.

The SRSA includes the Counties of Shasta, Tehama, Glenn, Butte, Colusa, Sutter, and Yolo. Water-based recreation within the SRSA service area is an important source of economic activity to the local and regional economies.

The Sacramento River traverses the interior of the SRSA and serves as its primary hydrologic feature. Other major recreational resources include federal, state, and locally operated reservoirs and lakes, and major tributaries to the Sacramento River. Federal recreation facilities include Shasta, Whiskeytown, and Clair Engle Reservoirs. Lake Oroville is an SWP facility. Other important reservoirs and lakes include East Park, Stony Gorge, and Black Butte Reservoirs. Tributaries to the Sacramento River within the service area that provide significant recreation use include Butte, Chico, Battle, Deer, Cottonwood, Stony, Cache, and Putah Creeks; and the McCloud, Pit, and Feather Rivers.

Five public waterfowl hunting areas within the SRSA provide substantial use for hunting and other activities: Gray Lodge Wildlife Management Area, Sacramento National Wildlife Refuge, Sutter National Wildlife Refuge, Colusa National Wildlife Refuge, and Delevan National Wildlife Refuge.

Of these water bodies and wildlife areas, water contracting alternatives being considered by the CVP could directly affect recreation at the Sacramento River, Shasta Reservoir, and the five wildlife areas. In addition, CVP water contracting alternatives would affect recreation at Clair Engle Reservoir in Trinity County. These recreation sites are described below.

Recreation Sites

Shasta Reservoir

Shasta Reservoir has a highly developed system of recreation facilities. Approximately 26 launches and docks and 13 marinas accommodate boating. Houseboating is an important recreation activity, attracting visitors from metropolitan areas as far away as Los Angeles and Seattle. Other facilities include resorts, cabins, motels, and restaurants. In 1985, water-dependent use at Shasta Reservoir totaled 4.1 million visitor-days. A recreation visitor-day equals 12 person-hours of recreation use. Other important recreation activities include camping, hiking, hunting, and nature appreciation. Recreation use at Shasta Reservoir is highly seasonal, with approximately 75 percent of annual use occurring between Memorial Day and Labor Day (McMorran pers. comm.).

Effects of reservoir storage level changes on recreational use at Shasta Reservoir are relatively minor until the water surface has been drawn down at least 80 feet, to a volume of 2,577,800 af. As the reservoir approaches this level, marinas are forced to move to new locations or to cease operations. Additional movements may be required when the reservoir is drawn down 100 feet, to a volume of 2,189,800 af (Hodgson and Schramel 1985).

Clair Engle Reservoir

Clair Engle Reservoir is located in Trinity County. It impounds the Trinity River, with a capacity of 2.5 million af and a surface area of about 17,000 acres. Clair Engle Reservoir can be reached by traveling north from U. S. 299 on State Highway 3.

Clair Engle Reservoir features steep montane landscape characteristic of the Trinity Mountains. The natural appearance of its shoreline is disturbed by only a few recreation facilities. Most of the shoreline is inaccessible by auto.

One full-service marina and several other marinas facilitate boating on Clair Engle Reservoir. Additional facilities include three boat access campgrounds and five public boat launches. The reservoir provides houseboating and other boating for local users and for visitors, most of whom reside in Humboldt County. Fishing, hunting, camping, and other dispersed outdoor recreation activities take place on and around Clair Engle Reservoir. Most of this use involves overnight visits. Total water-dependent use in 1985 was about 1,373,000 visitor-days.

Approximately 80-85 percent of annual use occurs between Memorial Day and Labor Day weekends.

Major marina moves are required at Clair Engle Reservoir when its surface is drawn down more than 60 feet, to a volume of 1,737,766 af. Additional marina movements may be required when the surface is drawn down 75 feet, to a volume of 1,621,241 af (Hodgson and Schramel 1985).

Sacramento River

The Sacramento River flows south from Lake Shasta through the Central Valley of northern California. Between Shasta Dam and Redding, the river flows between I-5 and U. S. 299. I-5 runs parallel to the river from Redding to Sacramento.

Upper Reach (Shasta Dam to Red Bluff). Principal recreation sites along the upper reach include Caldwell Memorial Park, Turtle Bay Recreation Area, Kutras Park, Anderson River Park, Ball's Ferry Bridge, Jelly's Ferry river access, Bend Bridge, Ide Adobe State Historic Monument, Red Bluff Marina and Park, and Red Bluff Diversion Dam recreation access.

Total recreation participation on this reach below Keswick Dam was estimated at about 1.1 million hours in 1980. The four activities considered to be water dependent in this analysis--swimming, boating, fishing, and picnicking--account for 52 percent of all recreation along this reach. Three-fourths of the participation originated in Shasta and Tehama Counties (California Department of Water Resources 1982). The reach between Shasta Dam and Keswick Dam consists primarily of Keswick Reservoir. Recreational facilities at Keswick Reservoir are minimal and accommodate only low use.

Middle Reach (Red Bluff to Colusa). Primary public recreation areas along the middle reach include Mill Creek fishing access, Woodson Bridge State Recreation Area, Tehama County River Park, Bidwell River Park, Shannon Slough Wildlife Area, Ord Ferry Park, and Jacinto Wildlife Area.

Total recreation participation along this reach in 1980 was estimated at 674,000 hours. Water-dependent activities accounted for 73 percent of the total (California

Department of Water Resources 1982). About 65 percent of recreation use was by residents of local counties.

Lower Reach (Colusa to Sacramento). Public recreation areas along the lower reach include the Colusa-Sacramento River Recreation Area, Colusa Weir and Tisdale Weir access, River Bend Public Boating Facility, Knights Landing, Sacramento Bypass, and the Elkhorn Boating Facility.

Total recreation use in 1980 was an estimated 2.31 million hours, with 80 percent accounted for by water-dependent activities. Three-fourths of the participation originated in local counties.

Trinity River

The Trinity River runs approximately 20 miles southwest of Mount Shasta and flows 170 miles southwest and then northwest to its confluence with the Klamath River 44 miles from the Pacific Ocean.

Much of the river immediately below Lewiston Dam is bordered by private land. Downstream from Douglas City, however, landownership is almost entirely federal, and the river is readily accessible to the public. Several campgrounds and resorts facilitate its use for various recreation activities.

Total recreation use of the reach between Lewiston Dam and the North Fork was estimated at 72,800 visitor-days in 1977 (U. S. Fish and Wildlife Service 1980). About 85 percent of this use was accounted for by swimming, picnicking, and sightseeing.

Colusa National Wildlife Refuge

Colusa National Wildlife Refuge consists of 4,040 acres located 0.5 mile southwest of Colusa in Colusa County, just south of State Highway 20. Annual waterfowl use at the Colusa National Wildlife Refuge was approximately 16.8 million days in 1980 and 1981. An average of 3,687 waterfowl hunters used the refuge over the past 10 years. In 1985, total hunting and fishing accounted for 4,100 use-days, and nonconsumptive recreation totaled 3,100 use-days.

Delevan National Wildlife Refuge

Delevan National Wildlife Refuge is located about 7 miles east of Maxwell, between I-5 and the Sacramento River in Colusa County. About 47 million waterfowl use-days occurred within the refuge in 1980-1981.

Delevan National Wildlife Refuge can accommodate up to 100 hunters at a time. Waterfowl attracted an average of 5,369 hunters to the refuge annually over the past 10 years. In 1985, all hunting and fishing accounted for 6,600 use-days, while other recreation activities amounted to 3,600 use-days.

Sacramento National Wildlife Refuge

Sacramento National Wildlife Refuge is located between I-5 and the Sacramento River, 5 miles south of Willows in Glenn and Colusa Counties. It supported about 63 million waterfowl use-days in 1980-1981.

Hunter capacity at the Sacramento National Wildlife Refuge is between 172 and 284, depending on the number of hunters per blind. Both free roaming and hunting from blinds are permitted. Over the past decade, 5,918 waterfowl hunters used the refuge annually. In 1985, total hunting and fishing accounted for 7,000 use-days. Other activities totaled 32,900 use-days.

Sutter National Wildlife Refuge

Sutter National Wildlife Refuge is located primarily within the Sutter Bypass, about 8 miles southwest of Yuba City in Sutter County. No other public wildlife management areas exist within the 57,000-acre Sutter basin. Over 9.4 million days of waterfowl use occur within the refuge in an average year.

Sutter National Wildlife Refuge can accommodate up to 80 hunters. About 2,821 waterfowl hunters use the refuge in an average year. All hunting and fishing resulted in 3,600 recreation use-days in 1985.

Gray Lodge Wildlife Management Area

Gray Lodge Wildlife Management Area is located off U. S. 99 in the Butte basin, about 10 miles southwest of Gridley within Sutter and Butte Counties. In the late 1970s, its waterfowl population ranged from 500,000 to 1,000,000 birds.

Gray Lodge Wildlife Management Area can accommodate up to 400 hunters, making it the largest public hunting area in the Sacramento Valley. In 1985, total hunting and fishing in the area was estimated at 29,800 use-days, while other forms of recreation accounted for 135,400 use-days.

AESTHETICS

Sacramento River Service Area

Introduction

This section defines aesthetic resources and generally describes the interaction between aesthetic and other resources. It focuses on the aesthetic values of the Sacramento River and Shasta and Clair Engle Reservoirs, the water bodies that would be most directly affectd by water contracting from a regional perspective.

Interaction of Aesthetics and Other Resources

The aesthetic value of a landscape is affected by both how the landscape looks, and how natural processes operate (Dunne and Leopold 1978). All of the natural and man-made features of a landscape contribute to its perceived image and aesthetic value. Unique in this respect, aesthetics are influenced by geologic, hydrologic, botanical, wildlife, fishery, recreational, and urban features. For example, vegetation along a river can create a focus or add contrast to a viewscape. Vegetation can also serve to frame views or buffer the viewer from unsightly images. Recreational features can affect the aesthetics of a viewscape by attracting people to the area, potentially increasing the aesthetic appeal of the area to recreationists while diminishing the aesthetic appeal for those seeking solitude or an area dominated by natural features.

Methods and Terms Used to Define Aesthetic Resources

Many methods have been developed to characterize or measure the scenic quality of a viewscape and the sensitivity of that resource to impacts (U. S. Bureau of Land Management 1980; U. S. Soil Conservation Service 1981; U. S. Forest Service no date; Litton 1974; Dunne and Leopold 1978; Jones 1975). The proper methods to identify aesthetic quality and assess visual impacts have been debated for years, but there has been no general agreement regarding the proper criteria to be employed in a methodology.

Litton (1974), Dunne and Leopold (1978), and Jones (1975) each identified three components of the landscape that influence the nature and intensity of a visual resource. Although these authors differ somewhat in terminology, their approaches are similar. The three components they use to describe the appearance of a scene are:

- o Intactness: a measure of the degree to which a landscape appears natural
- o Vividness: the memorability of the visual impression received from the viewscape or its elements

- o Unity: a measure of the degree to which individual elements in the viewscape join together to form a single, coherent, and harmonious visual unit.

Water, whether in a city or a wilderness, is a powerful visual element that often represents a major component of the visual resource, and it can influence many other components. Although important aesthetically, water corridors are difficult to define or measure, and any aesthetic evaluation of such corridors includes at least a partial subjective judgment derived from the observer's state of mind and the context of the observer (Litton et al. 1974). Images can vary significantly not only throughout the seasons but also on an hourly basis as light and shadow merge and change.

There are three major viewsheds that could be affected by Bureau water contracting in the SRSA area: Shasta Reservoir, Clair Engle Reservoir, and the Sacramento River from Keswick Dam to the Delta. In addition, secondary effects could occur in association with agricultural development or urban growth in upland areas. The paragraphs below summarize the present visual conditions in each of these areas.

Other visual corridors such as the Trinity River valley and Whiskeytown National Recreation Area are not discussed because river flows and reservoir elevations would not be affected.

Sacramento River

In the Central Valley of California there is very little natural landscape remaining. Today's landscape is dominated by intensive agriculture or urban uses. Although there are some positive visual features to this landscape, the river corridor provides vivid visual contrast and relief from the remainder of the valley landscape and represents a significant aesthetic resource.

The river can be divided into three visual reaches for aesthetic analysis, the first reach being from the Keswick Dam downstream to Red Bluff, the second from Red Bluff to Colusa, and the third from Colusa downstream to the Delta. In the first reach, the river winds through the forested floodplain from Redding down past Anderson to the confluence with Cottonwood Creek. Below Cottonwood Creek the river is confined within foothill canyons as it winds its way to Red Bluff. Although urban development is scattered along the uppermost section of this reach the river retains a natural visual character, revealing a variety of vivid images created by the fast-flowing water, coupled with the riffles, pools and many meanders that occur as this large river winds its way downstream.

From Red Bluff to Colusa, the natural character of the river remains fairly intact as it migrates through alluvial deposits. The lower section of this reach is leveed but the levees are generally set back from the river. There is also a large amount of woody riparian vegetation remaining along the river which, in combination with the wide riffles and pools found along the river meanders in this reach, create a variety of views which are intact and vivid.

From Colusa to the Delta the river gradually loses its natural character. Levees border the river except where they are set back at major meanders. Meanders are more confined and there are fewer point bars. The river corridor exhibits less variety because of its more constant depth, width, and velocity in the confined channel typical of this reach. Some locations in this reach have more mature riparian vegetation which, in combination with the large and wide river conditions, create striking visual images; however, along many sections vegetation is severely limited. In general, the aesthetic character of this reach is not considered distinctive.

Shasta Reservoir

Shasta Reservoir is the largest artificial reservoir in the state. It is part of the Whiskeytown-Shasta-Trinity National Recreation area in the Shasta-Trinity National Forest. The reservoir is a heavily used recreational resource (see the "Recreation" section of this chapter) and the reservoir is visible from I-5, the major transportation link from Oregon to California. I-5 has been designated as eligible for state scenic highway designation in studies done by Caltrans (Vogel pers. comm.).

Based on the variety of views in the viewshed and estimates of public concern for scenic quality (sensitivity levels) the U. S. Forest Service has established visual quality objectives for the viewshed as seen from the reservoir and the I-5 visual corridor, which includes views of Shasta Reservoir. The visual quality management objectives for these viewsheds call for retention of present visual quality (U. S. Forest Service 1986). In keeping with these objectives, U. S. Forest Service land management activities are required to have no visually evident impact.

Shasta Reservoir is drawn down each year as stored water is released for use downstream. The drawdown creates a "bathtub ring" of bare dirt on the perimeter of the reservoir. This drawdown averages about 67 feet but was 231 feet in 1977 based on hydrologic modeling. Drawdown has a significant effect on the aesthetic quality and the recreational value of the reservoir.

Clair Engle Reservoir (Trinity Lake)

Clair Engle Reservoir is surrounded by forested mountains with snow-capped peaks. The U. S. Forest Service gave the visual quality of the Trinity Lake viewshed the highest rating possible using its visual resource management methodology. The U. S. Forest Service also rated the viewshed as highly sensitive to disturbance because of the recreational values of the area and the wilderness status of adjacent lands. Typical drawdowns in Clair Engle Reservoir average 81 feet but have been as much as 249 feet in the driest years based on hydrologic modeling. As in Shasta Reservoir, the bathtub ring formed by the drawdown has a significant effect on the aesthetic quality and recreational value of the reservoir.

Site-Specific Service Areas

In the SRSA, water was requested for urban development in Shasta, Yolo, and Solano Counties and for agricultural development in Tehama, Glenn, Colusa, Yolo, and Solano Counties. The scenic resources of concern in these site-specific service areas include scenic open space corridors along rural roadways and major highways and bufferland agricultural open spaces surrounding urban areas.

ECONOMICS

Sacramento River Service Area

This section describes the economic setting and activity of the SRSA. It characterizes the type of agriculture in terms of crop acreage and values, and the major industries in terms of employment within each county. Economic activity related to recreation, although not discussed in this section, would be affected by water contracting and is evaluated in the "Economics" section of Chapter 4.

The affected economic environment for the SRSA includes Butte, Colusa, Glenn, Sacramento, Shasta, Solano, Sutter, Tehama, Yuba, and Yolo Counties. Except for Sacramento County, agriculture is the dominant land use in the area, though not always the largest source of income or employment. Table 3K-1 shows crop acreage and crop value for each county in the service area.

The irrigated area in the counties north of Yolo and Sacramento Counties is expected to remain at current levels, or higher, depending on water supply and commodity prices. Population projections from the California Department of Finance show moderate growth in the northern counties and much faster growth in Solano and Sacramento Counties (Table 3K-2). This population growth is expected to result in significant conversion of cropland to urban uses, with consequent shifts in sources of income and employment.

Counties

Butte County

In the portion of the county lying in Sacramento Valley, conditions for agriculture are very favorable. Grains are the most important crops, with rice accounting for about 25 percent of the value of the county's agricultural production. Fruits and nuts are also important crops, principally almonds, prunes, peaches, and walnuts.

Chico, the largest city in the county, serves as a trade center for the surrounding agricultural area. California State University at Chico has an enrollment of 13,000. The Oroville area has lumber and wood products, food services, and services associated with the surrounding recreational areas.

Colusa County

Colusa County is primarily devoted to agriculture. The principal crops include rice, tomatoes, sugar beets, prunes, and nuts. Employment in the area is expected to remain stable.

Table 3K-1. Crop Area and Values by County for 1985:
Sacramento River Service Area

County	Vegetables		Fruit & Nut		Field Crop	
	Area (ac)	Value ($ 1,000)	Area (ac)	Value	Area (ac)	Value ($ 1,000)
Butte	0	0	65,121	N/A	107,200	43,757
Colusa	10,100	53,296	22,674	N/A	152,800	64,507
Glenn	0	0	26,930	N/A	128,200	47,941
Sacramento	3,900	20,580	10,461	N/A	84,600	34,560
Shasta	0	0	2,935	N/A	3,200	541
Solano	12,000	61,434	13,441	N/A	131,700	51,266
Sutter	15,800	82,618	43,170	N/A	170,900	66,895
Tehama	0	0	34,141	N/A	22,800	2,320
Yuba	0	0	21,595	N/A	28,300	12,230
Yolo	43,500	229,541	21,253	N/A	172,100	60,890

N/A = not available

Source: California Crop and Livestock Reporting Service 1986a,b; California Agricultural Statistics Service 1988

Table 3K-2. Economic Statistics:
Sacramento River Service Area

County	1985 Population (thousands)	2020 Population (thousands)	1984 Personal Income (million $)	1985 Employment (thousands)	Major Employing Sectors
Butte	164.0	296.1	1,640.2	50.4	Retail and Services, Government
Colusa	14.7	23.0	169.8	5.9	Agriculture, Government
Glenn	23.2	32.0	259.4	7.9	Agriculture, Government, Manufacturing
Sacramento	893.8	1,511.7	11,208.7	499.8	Government, Retail and Services
Shasta	131.7	227.3	1,362.6	39.3	Retail and Services, Government
Solano	275.2	520.9	3,427.9	83.4	Government, Retail and Services
Sutter-Yuba[a]	112.8	155.1	1,114.6	32.7	Government, Retail and Services, Agriculture
Tehama	44.3	77.4	418.4	11.8	Manufacturing, Government
Yolo	124.0	182.1	1,438.8	53.5	Government, Retail and Services

[a] Sutter and Yuba Counties are reported as Yuba City S.M.S.A.

Source: California Department of Finance 1986
California Development Department 1987, 1988

Glenn County

About 41 percent of the Glenn County residents are located in Willows and Orland. At the lower elevations, the county's terrain, favorable weather, and water supply create very favorable conditions for agriculture, the major industry in the area. Grains are the most important crops, with rice accounting for a large part of the value of the county's agricultural production. Dairy farms are also an important source of income. The growth of local manufacturing (the third largest industry) has been closely tied to development of the county's agricultural and forestry production. Lumber mills, dairy processors, packers of fruits and nuts, and sugar refiners have all been attracted to Glenn County by an abundance of raw commodities for processing.

Sacramento County

Sacramento County has a fairly diversified economy. Trade and services together provide more than 40 percent of all jobs, and government provides another 33 percent. Food processing is the most important manufacturing industry, although manufacturing of other nondurable goods and a variety of durable goods industries also provide a substantial number of jobs. Sacramento is located at the intersection of three major highways; this location, in addition to the availability of major rail, water, and air transportation facilities, contributes to Sacramento's historic reputation as a center of commerce.

Sacramento County population and employment have grown rapidly. Population in Sacramento County increased by 15.6 percent from 1980 to 1986, compared with 12.5 percent in the state. Although substantial gains were reported in most portions of the county, the area with the highest rate of growth during this period was the City of Folsom. Employment growth exceeded increases in the labor force by a wide margin over the past 3 years, reducing the number of unemployed by more than 30 percent. The unemployment rate fell during this period from 9.6 to 6.0 percent. Services, government, retail trade, and construction all provided a substantial number of these new jobs.

Sacramento County agricultural lands are devoted predominantly to field crops, primarily corn, wheat, and rice. However, in terms of crop value, the major crops in the county are pears, grapes, and tomatoes.

Shasta County

Redding is a primary trade and commerce center for the northcentral and northeastern portion of California. Indications of sustained growth in the cities and county as a whole include increases in educational employment accompanied by expansion of the construction, services, retail trade, and manufacturing industries.

The Sacramento River is part of a large network of tributary rivers and streams that feed Shasta Lake in the Whiskeytown-Shasta-Trinity National Recreational Area. The area, along with Shasta and Lassen National Forests and Lassen Volcanic National Park, is a major economic resource.

Strawberries, a major crop in this county, are exported to southern Europe. Apiary products, exported to Canada, and orchards are just a few of the important sources of agricultural income. Vast timberlands provide jobs in the lumber industry.

Solano County

Vallejo is Solano County's largest city. It is bordered on the west by Mare Island Naval Shipyard, the Napa River, and marshland. To the east are rolling hills separating the city from the valley portion of the county. Both Vallejo and Benicia, an industrial center, offer important deepwater ports for the Bay Area. Fairfield is the county seat and second largest city in the county. It is bordered by Travis Air Force Base, one of the larger Air Force installations on the West Coast. The Vacaville-Dixon area of the county is a center for grain, field crops, livestock, and food processing operations.

Sutter and Yuba Counties

The Yuba City Metropolitan Statistical Area encompasses Sutter and Yuba Counties and lies in the heart of the Sacramento Valley. The leading industries in these counties in terms of employment are government and retail trade and services. Much of the land is devoted to agriculture, which is the third largest industry from an employment viewpoint in the area. A wide variety of crops are produced including tomatoes, rice, peaches, prunes, nuts, and other grains.

Tehama County

The rich bottomlands of Tehama County produce a large percentage of the state's almonds, walnuts, and prunes. Olives, peaches, strawberry plants, and various grain crops are also grown in the county. With an abundance of pasture and rangeland, Tehama County also has a significant sheep and cattle industry. The vast timberlands, both on the east and west sides of the valley, provide a wealth of timber for various types of lumber operations in the county.

Major industries in terms of employment in the county include manufacturing, lumber and wood products, retail trade, services, and government.

Yolo County

Yolo County's economy is primarily agricultural, with a relatively high number of jobs based on activities relating to the production or processing of farm products. However, a number of other manufacturing industries in the county provide a substantial number of jobs. The University of California at Davis has an enrollment of 22,000.

C-055627

LAND USE

Sacramento River Service Area

Introduction

This section briefly describes existing land uses in the SRSA. It also describes land use issues that could be related to water contracting actions.

Land Uses

Land uses in the SRSA are varied and include substantial agricultural and urban components. Generally, urban uses are concentrated in the northern and southern ends of the service area in Shasta and in Yolo and Solano Counties, respectively. The central part of the SRSA is dominated by agricultural lands although many small communities are interspersed.

Place of Use

Reclamation holds several water right permits from the SWRCB to divert and use the waters of the state. The permits contain several conditions that the permittee must comply with according to state law. A water right permit generally specifies the amount of water that may be diverted, the purposes for which the water may be used, the points where the water may be diverted, the time of year when the diversions may be made, and the geographical area where the water may be used.

Most Reclamation water right permits include place of use provisions. For Reclamation irrigation uses in the SRSA, the water right permits specify an outer boundary (in gross acres) within which water may be used. The geographic location of the net acres may change from year to year without SWRCB approval as long as the irrigated acreage remains within the boundaries defining the gross acreage and the amounts of water used do not exceed those allowed in the water right permits.

Reclamation has recently petitioned the SWRCB to amend its existing water right permits for all CVP facilities. The amended permits would consolidate the CVP places of use, allowing Reclamation to serve any area within the total CVP service area with any CVP facility physically capable of serving that area. Current SWRCB permits restrict service certain areas to particular CVP facilities, thus limiting flexibility to manage and operate the system. Under the proposed permit amendments, the place of use would also be expanded from approximately 13,000,000 gross acres to approximately 17,000,000 acres. (See "Related Activities" in Chapter 1 for additional information.) In the SRSA, this change would increase the outer boundary of the permitted place of use.

Table 3L-1 identifies those agencies requesting water that have lands outside the current place of use.

Table 3L-1. Site-Specific Land Use Information:

Sacramento River Service Area

Agency	Existing Land Uses	Consistency with Existing Place of Use	Status of Bureau Land Classification Studies	Floodplains and Wetlands Within Agency Boundary	Prime or Unique Farmlands Within Agency Boundary
Shasta Dam Area Public Utility District	Urban and developed lands.	224 acres in the northern portion of the district are outside existing place of use.	N/A	Floodplains and wetlands are present.	None was identified.
Sacramento Valley Canals Agencies					
Colusa County Water District	Includes 46,100 acres. 40,000 acres are irrigated. Nonirrigated lands include grain, native pasture, and fallow land.	Approximately 2,250 acres located in the southwestern portion of the district are outside the existing place of use.	Classification complete. Lands include Classes 1-6.	Wetlands are present.	N/A
Corning Water District	Includes 14,000 acres. 7,000 acres are irrigated. Nonirrigated lands are dryland farmed and grazed. District includes commercial agricultural operations, as well as small 1- to 10-acre ranchette or hobby farms.	Approximately 1,650 irrigated acres located in the western portion of the district are outside the existing place of use.	Classification complete. Lands include Classes 1-6.	Wetlands are present.	N/A
Dunnigan Water District	Includes 10,500 acres. 7,600 acres are irrigated, and 8,000 acres have distribution lines for eventual irrigation. Nonirrigated lands are dryland farmed and grazed.	Consistent	Classification complete. Lands include Classes 1-6.	Wetlands are present.	N/A
Glenn-Colusa Irrigation District	Includes 13,200 acres, 7,900 of which are irrigated. Remaining lands are dryland farmed or grazed.	Consistent	Classification complete. Lands include Classes 1-6.	Wetlands are present.	N/A

C-055629

Table 3L-1. Continued

Agency	Existing Land Uses	Consistency with Existing Place of Use	Status of Bureau Land Classification Studies	Floodplains and Wetlands Within Agency Boundary	Prime or Unique Farmlands Within Agency Boundary
<u>Glenn County Lands</u>					
Glide Water District	Includes three parcels consisting of approximately 1,000 acres that are outside existing district boundaries. Land is dryland farmed and grazed.	Consistent	Lands are not classified.	Wetlands are present.	N/A
Kanawha Water District	Includes 4,000 acres of land outside district boundaries. Land is dry-land farmed and grazed.	About 1,000 acres are outside the existing place of use.	Lands are not classified.	Wetlands are present.	N/A
Orland-Artois Water District	Includes 4,000 acres out-side district boundaries. Land is dryland farmed and grazed. Some limited groundwater irrigation.	About 160 acres are outside the existing place of use.	Lands are not classified.	Wetlands are present.	N/A
Willow Creek Mutual Water Company	Includes 500 acres outside district boundaries. Land is presently in wetland vegetation and used for waterfowl habitat. Some grazing also occurs.	Consistent	Lands are not classified.	Wetlands are present.	N/A
Glide Water District	Includes 9,400 acres. 3,900 acres are irrigated. Non-irrigated lands are dryland farmed and grazed.	Consistent	Classification complete. Lands include Classes 1-3 and 6.	Wetlands are present.	N/A
Holthouse Water District	Includes 1,700 acres. 475 acres are irrigated. Non-irrigated lands are grazed or fallow.	Consistent	Lands include Classes 2, 3, and 6. Some areas not classified.	Wetlands are present.	N/A
Orland-Artois Water District	Includes 31,273 acres. 20,200 acres are irrigated. Nonirrigated land is dry-land farmed or grazed.	Approximately 160 acres located in the western portion are outside the existing place of use.	Classification complete. Lands include Classes 1-3 and 6.	Wetlands are present.	N/A

C-055630

Table 3L-1. Continued

Agency	Existing Land Uses	Consistency with Existing Place of Use	Status of Bureau Land Classification Studies	Floodplains and Wetlands Within Agency Boundary	Prime or Unique Farmlands Within Agency Boundary
Rancho Saucos Water District	Includes one parcel.	Consistent	Classification complete. Lands include Classes 1-3 and 6.	Wetlands are present.	N/A
Tehama Ranch Mutual Water Co.	Includes 875-acre ranch. 490 acres are irrigated.	Consistent	Classification complete. Lands include Classes 1-3 and 6.	Wetlands are present.	N/A
Yolo-Zamora Water District	Includes 26,900 acres. 15,700 acres are irrigated.	Approximately 128 acres located in the southwestern portion of the district are outside the existing place of use.	Classification complete. Lands include Classes 1-3 and 6.	Wetlands are present.	N/A
<u>Yolo-Solano CVP Water Service Coordinating Group</u>					
Woodland, City of	Urban	Consistent	N/A	Wetlands are present.	N/A
Davis, City of	Urban	Consistent	N/A	Wetlands are present.	N/A
Yolo County Flood Control and Water Conservation District	Includes 193,100 acres of irrigated and nonirrigated farmlands.	About 9,310 acres in the northwest portion of the district (Capay Valley) are located outside the existing place of use.	Lands are not classified.	Wetlands are present.	N/A
Benicia, City of	Urban	Consistent	N/A	Wetlands are present.	N/A
Dixon, City of	Urban	Consistent	N/A	Wetlands are present.	N/A
Fairfield, City of	Urban	Consistent	N/A	Wetlands are present.	N/A
Vallejo, City of	Urban	Consistent	N/A	Wetlands are present.	N/A
Rio Vista, City of	Urban	Consistent	N/A	Wetlands are present.	N/A
Suisun City, City of	Urban	Consistent	N/A	Wetlands are present.	N/A
Vacaville, City of	Urban	Consistent	N/A	Wetlands are present.	N/A

C-055631

Table 3L-1. Continued

Agency	Existing Land Uses	Consistency with Existing Place of Use	Status of Bureau Land Classification Studies	Floodplains and Wetlands Within Agency Boundary	Prime or Unique Farmlands Within Agency Boundary
Collinsville area	Agricultural and industrial.	Consistent	N/A	Wetlands are present.	N/A
Wildlife Refuges					
Delevan NWR	Includes 5,600 acres. Wildlife refuge consists of ponds, millet fields, and irrigated pasture.	Consistent	N/A	Wetlands are present.	N/A
Colusa NWR	Includes 4,000 acres of ponds, millet and rice fields, cropland, and upland areas.	Consistent	N/A	Wetlands are present.	N/A
Sutter NWR	Includes 2,600 acres of ponds, rice and millet fields, and uplands. Located in Sutter Bypass.	Consistent	N/A	Wetlands are present.	N/A
Gray Lodge WMA	Includes 8,400 acres of marshlands, ponds, wheat fields, and uplands.	Entire refuge is located outside the existing place of use.	N/A	Wetlands are present.	N/A
Sacramento NWR	Includes 10,800 acres of ponds, rice fields, and millet fields.	Consistent	N/A	Wetlands are present.	N/A

N/A = Not applicable.

C-055632

Irrigable Lands

Reclamation regulations and law require that all agricultural lands proposed by an agency to receive CVP water must have an approved land classification to be eligible to receive CVP water. Land classification studies required by Reclamation are intended to determine whether lands proposed for irrigation will provide sufficient income to warrant consideration for irrigation development. These are lands that will generate sufficient income under irrigation to pay all farm production expenses, provide a reasonable return, and at least pay the operation and maintenance costs of associated irrigation and drainage facilities.

Land classification studies result in lands being placed into one of five categories. Class 1, 2, 3, and 4 lands are arable and generally considered irrigable. Class 6 lands are not considered economically feasible to irrigate and are ineligible to receive Bureau water. (Class 6 lands also include roads, canals, and other improvements.) In addition, lands for which a land classification study have not been undertaken also are ineligible for Reclamation water until such a classification is completed. The criteria for determining economic feasibility for irrigable lands are somewhat flexible. Lands currently identified as Class 6 may be reclassified and become eligible to receive CVP water if the district or landowner can show that the land supports a crop that provides a reasonable economic return. Table 3L-1 identifies the status of land classification studies for those agencies requesting irrigation water.

Floodplains and Wetlands

Federal agencies are required under Executive Order (EO) 11988, Floodplain Management, and EO 11990, Protection of Wetlands, to assess the effects of agency actions on the beneficial values of these resources.

EO 11988 requires federal agencies to prepare floodplain assessments for proposals located within or affecting floodplains. If an agency proposed to conduct an action within or affecting a floodplain, it must consider alternatives to avoid adverse effects and incompatible development in the floodplain. If the only practicable alternative affects the floodplain, the agency must minimize potential harm to the floodplain and explain why the action is proposed.

EO 11988 is designed primarily to reduce the risk of flood hazards that could result from actions undertaken by federal agencies in urban areas. The principal effect associated with water contracting would occur where urban growth would be directly accommodated or induced by the provision of CVP water and where that growth would occur in a designated floodplain. Such accommodation of growth occurs under the water contracting alternatives only where growth within an entity is water constrained. These entities provide M&I water supplies and have no alternative supply; therefore, future growth can be directly attributed to the provision of CVP water. In the SRSA, the Shasta Dam Area Public Utility District is the only area considered water constrained. Therefore, the assessment of floodplain occurrence focuses on this agency.

EO 11990 requires federal agencies to prepare wetlands assessments for proposals located within or affecting wetlands. Agencies must avoid undertaking new construction within wetlands unless no practicable alternative is available and the proposed action includes all practicable measures to minimize harm to wetlands.

Table 3L-1 identifies those agencies requesting CVP water with wetlands and floodplains that may be affected by CVP water contracting.

Prime and Unique Farmlands

Federal agencies proposing actions are required by CEQ Memoranda to Heads of Agencies (dated August 30, 1976, and August 11, 1980) and by the Farmlands Protection Policy Act of 1981 to include assessments of the adverse effects of their actions on the preservation of prime and unique farmlands as defined by SCS in EIS's. These regulations are designed to identify where such lands would be converted from agricultural to urban uses and where such conversions are directly associated with federal actions. The presence of prime and unique farmlands was therefore assessed for the Shasta Dam Area Public Utility District only. Table 3L-1 identifies those M&I agencies requesting CVP water with prime or unique farmlands that could be affected by CVP water contracting.

Site-Specific Service Areas

Table 3L-1 describes current land uses and contains information on consistency with the existing and proposed place of use, consistency with Reclamation's irrigable land classifications, and occurrence of floodplain and wetlands for each of the agencies requesting water in the SRSA.

C-055635

POPULATION GROWTH AND RELATED SOCIAL IMPACTS

Sacramento River Service Area

Introduction

This section discusses existing population trends within the SRSA. Since population growth generates potential secondary effects by increasing demand for housing, adding to traffic volumes on local roads, and decreasing air quality, these topics are also discussed within this section.

Much of the data discussed throughout this section represent conditions existing in 1985 and projected to exist in 2015. The year 1985 was used to represent base-year, or existing, conditions because it was the most recent year for which hydrologic data was available for use in this study. The year 2015 was used to represent future conditions for population and social effects because it corresponds with the 25-year time horizon for M&I contracts used in Technical Appendix A - Water Needs Analysis as described in Chapter 2.

Population

Recent population growth in the SRSA has been most pronounced at the northern and southern ends of the region. Table 3M-1 presents recent population trends in the SRSA.

Growth projections to 2015, presented in Table 3M-2, indicate that counties at the northern and southern extremes of the SRSA, including Shasta, Yolo, and Solano Counties, will continue to experience the greatest growth among the six counties potentially affected by new or expanded CVP water contracts.

Housing

Within the SRSA, housing stocks are largest in the three most populated counties: Shasta, Yolo, and Solano. Table 3M-3 shows existing housing units and trends in the SRSA.

Based on the population growth projections shown in Table 3M-2, approximately 164,000 additional dwelling units (du) will be required to accommodate the projected population increase in the six-county area by 2015 (Table 3M-3). An estimated 90 percent of these housing units will be required in Shasta, Yolo, and Solano Counties.

Traffic

The highway system in the SRSA consists of interstate routes, California state routes (SR), and U. S. highways. The pattern of freeways generally can be described as a system

Table 3M-1. Population Trends of Counties and Cities
Potentially Affected by Expanded or New CVP Water Contracts

Agency	1970	1980	1985	Percent Change 1970-1985	Compounded Percentage Growth Rate
Counties					
Shasta County	77,640	115,715	129,700	67.1	3.5
Tehama County	29,517	38,888	43,800	48.4	2.7
Glenn County	17,521	21,350	22,950	31.0	1.8
Colusa County	12,430	12,791	14,450	16.3	1.0
Yolo County	91,788	113,374	122,600	33.6	1.9
Solano County	171,989	235,203	271,000	57.6	3.1
Cities					
Davis, City of	23,488	36,640	40,400	72.0	3.7
Woodland, City of	20,677	30,235	33,050	59.8	3.2
Dixon, City of	4,432	7,541	9,550	115.5	5.2
Vacaville, City of	21,690	43,367	50,200	131.4	5.8
Fairfield, City of	44,146	58,099	65,900	49.3	2.7
Suisun City, City of	2,917	11,087	13,900	376.5	11.0
Vallejo, City of	71,710	80,188	89,500	24.8	1.5
Benicia, City of	7,349	15,376	20,850	183.7	7.2
Rio Vista, City of	3,135	3,142	3,410	8.8	0.6

Sources: 1970 and 1980 data: U. S. Bureau of the Census.

1985 estimates: California Department of Finance 1986.

Table 3M-2. Population Projections to 2015 for Counties and Cities Potentially Affected by Expanded or New CVP Water Contracts

Agency	1985	2015	Percent Change 1985-2015	Compounded Percentage Growth Rate
<u>Counties</u>				
Shasta County	129,700	216,000	66.5	1.7
Tehama County	43,800	72,900	66.4	1.7
Glenn County	22,950	31,100	35.5	1.0
Colusa County	14,450	22,100	52.9	1.4
Yolo County	122,600	194,400	58.6	1.5
Solano County	271,000	519,000	91.5	2.2
<u>Cities</u>				
Davis, City of	40,400	74,700	84.9	2.1
Woodland, City of	33,050	60,300	82.5	2.0
Dixon, City of	9,550	17,000	78.0	1.9
Vacaville, City of	50,200	118,300	135.7	2.9
Fairfield, City of	65,900	138,300	109.9	2.5
Suisun City, City of	13,900	38,900	179.9	3.5
Vallejo, City of	89,500	129,700	44.9	1.2
Benicia, City of	20,850	32,000	53.5	1.4
Rio Vista, City of	3,410	10,700	213.8	3.9

Sources: 1985 estimates: California Department of Finance 1987.

2015 projections for Shasta, Tehama, Glenn, and Colusa Counties: California Department of Finance 1986.

2015 projections for Yolo County, Woodland, and Davis: Jones & Stokes Associates, Inc., based on Sacramento Area Council of Governments (1988) growth projections through 2010. Growth projected for Davis limited to 74,700 by an ultimate growth boundary adopted as part of the city's general plan.

2015 projections for Solano County and cities within Solano County: Jones & Stokes Associates, Inc., based on Association of Bay Area Governments (1987) growth projections through 2005.

Table 3M-3. Existing and Projected Housing for Counties and Cities Potentially Affected by Expanded or New CVP Water Contracts

Agency	1985	2015	Additional Housing Required 1985-2015
Counties			
Shasta County	53,270	85,700	32,430
Tehama County	18,600	29,780	11,180
Glenn County	9,170	12,200	3,030
Colusa County	5,870	8,660	2,790
Yolo County	47,410	75,560	28,150
Solano County	93,750	180,190	86,440
Cities			
Davis, City of	16,440	30,670	14,230
Woodland, City of	12,210	22,240	10,030
Dixon, City of	3,140	5,480	2,340
Vacaville, City of	16,600	40,290	23,690
Fairfield, City of	21,380	45,880	24,500
Suisun City, City of	4,410	11,920	7,510
Vallejo, City of	32,490	47,070	14,580
Benicia, City of	7,760	11,860	4,100
Rio Vista, City of	1,450	4,460	3,010

Sources: 1985 estimates: California Department of Finance 1986.

1985 projections: Jones & Stokes Associates, Inc., based on estimated 1985 average household sizes (California Department of Finance 1986) and population projections shown in Table 3M-2.

of interstate and major SRs radiating from Sacramento, the main metropolitan area in the Central Valley. These major facilities are interconnected by the minor, less-traveled state highways and provide access to cities in the Sacramento Valley, the San Joaquin Valley, the Sierra Nevada foothills, and the Bay Area.

The volume of traffic on highways in the SRSA varies widely from route to route and depends largely on the roadway's proximity to a major metropolitan area. Few projections of future traffic volumes are available. Table 3M-4 summarizes the volume of traffic for some highway segments in the SRSA. Volumes in Table 3M-4 are stated in terms of average daily traffic (ADT).

In addition to highways, the roadway system includes a network of streets under the jurisdiction of cities and counties. The typical city street system consists of major and minor arterials, collector streets, and local streets. These roadways provide direct access to residential, commercial, industrial, agricultural, and recreational areas.

Traffic problems in cities in the SRSA generally fall into three categories, according to where they occur: near freeway on- or off-ramps, in downtown areas, and along particular corridors.

Local traffic problems can also be categorized in terms of when they occur. Congestion commonly occurs during the a.m. or p.m. peak hour and during peak days such as holidays and weekends.

Although traffic conditions are closely related to traffic volumes, the capacity of a roadway determines how well it is able to handle the volume and what traffic conditions can be expected. A higher volume of traffic, however, generally results in more congestion. As a result, most congestion occurs in major metropolitan areas where intraregional trips cause more peak traffic incidents to occur.

Air Quality

The SRSA lies primarily within the Sacramento Valley air basin, bounded by the Coast Ranges on the west and the Sierra Nevada on the east. Portions of the SRSA are also just within the outer edge of the San Francisco Bay Area air basin.

Air Quality Planning Background. The federal Clean Air Act amendments of 1977 required that national ambient air quality standards be set for a variety of pollutants. These standards are divided into primary standards, which are designed to protect public health, and secondary standards, which are intended to guard the public against visibility reduction, soiling, and other nuisance factors.

Each state, including areas that were in violation of these standards, prepared a state implementation plan (SIP) which outlined programs for achieving compliance with the federal air quality standards by the December 31, 1987 deadline set by the Clean Air Act. Areas that failed to comply with the standards, as determined by review of official monitoring data, are officially designated by EPA as "nonattainment" areas.

Table 3M-4. Existing and Future Average Daily Traffic Volumes for Selected Highway Segments

Route	1986 ADT	2010 ADT
I-5 at SR 32	16,450	24,970
I-5 at SR 20	16,500	28,050
I-5 at I-505	12,650	36,225
I-5 at SR 16	19,500	46,000

Sources: 1986 ADT estimates: California Department of Transportation 1987.

2010 ADT estimates extrapolated from route concept reports published by the California Department of Transportation, 1984-1987.

Local Air Quality Planning Background. The SIP in California was prepared by the California Air Resources Board and encompassed locally prepared air quality management plans (AQMP). The AQMPs explain how nonattainment areas would comply with the air quality standards by the December 1987 deadline. The AQMPs generally differ by area, depending on geographic location and the pollutants of concern. The level of detail in each AQMP also varies substantially. The population projections, for example, may be presented at a general countywide level or maybe as detailed as by census-tract minor zone. Many local agencies help prepare the AQMP, including the regional planning agency, local air pollution control districts, and other planning agencies.

The SRSA includes all or portions of many air quality planning jurisdictions. Solano and Yolo Counties are classified by EPA as nonattainment areas for ozone standards, and the urbanized area of Solano County is classified by EPA as a nonattainment area for carbon monoxide standards. The AQMP for the San Francisco Bay Area includes parts of Solano County and showed that the area would attain the ozone and carbon monoxide standards by the December 1987 deadline. The AQMP for the Sacramento area, which includes portions of Solano County and all of Yolo County, predicted that the area would not attain the ozone standard by the deadline. Shasta, Tehama, Glenn, and Colusa Counties are in attainment of ozone or carbon monoxide standards and did not have to prepare an AQMP. None of the counties is classified as a nonattainment area for particulate matter.

Current Status Of Air Quality Planning. EPA is assembling a list of areas that have not met the federal ozone and carbon monoxide air quality standards and is preparing a post-1987 ozone/carbon monoxide policy. In 1989, EPA will require states not in compliance with the ozone or carbon monoxide standards to update their SIPs. Regulatory actions may be imposed on an area that has not updated its SIP, demonstrated near-term attainment, or implemented measures contained in its SIP. Construction bans on major new sources of air pollution could be regulatory actions for areas failing to meet standards, and federal funding for transportation projects, sewage treatment plants, and state air quality management efforts also could be withheld or limited.

EPA has already imposed construction bans on the Sacramento and Los Angeles areas for certain categories of industrial facilities. Few applications have been made for permits to construct such industrial facilities, however, because these areas have not been able to reduce other major sources of air pollution to offset the new air pollutant emissions as required by local AQMPs. Therefore, EPA's construction ban probably will not have substantial effect on air quality improvement efforts.

The Sacramento metropolitan area (including Yolo County and portions of Solano County) and San Francisco metropolitan area (including portions of Solano County) are included in EPA's list of areas exceeding the ozone standard between 1985 and 1987. The Fairfield urban area is included in EPA's list of areas having exceedences of the carbon monoxide standard during 1986 and 1987.

The Sacramento area is updating its 1982 AQMP. The AQMP, however, did not predict attainment of the ozone standards, so the Sacramento area is preparing a new AQMP, in advance of most other areas. Updating the AQMP involves complicated ozone modeling, and preparing a new plan could take more than a year. The San Francisco area is waiting for EPA to require updating of its AQMP.

Counties

Shasta County

The only agency requesting CVP water in Shasta County is the Shasta Dam Area Public Utility District, which is requesting water for M&I use. This district serves an unincorporated area of Shasta County north of Redding. The following discussions of population and housing conditions focus on countywide conditions.

Population. Shasta County is the most populated Sacramento Valley county north of Sacramento County, with an estimated 1985 population of 129,700. The population of the Shasta Dam Area Public Utility District is estimated to be 8,250, representing 6.4 percent of the county's population (U. S. Bureau of Reclamation 1988). The county's primary population centers are Redding (population 48,675) and Anderson (population 7,526). An estimated 55 percent of the county's population resides in unincorporated areas. DOF (1986) projects Shasta County's population to increase to 216,000 by 2015, which represents an annual 1985-2015 growth rate of 1.7 percent (Table 3M-2).

Housing. Shasta County's housing stock is estimated at 53,270 du in 1985. The county's estimated housing vacancy rate is 10.3 percent (California Department of Finance 1986). Based on population projections and an estimated countywide average household size of 2.66 in 1985, Shasta County would require a total housing stock of approximately 85,700 du by 2015. This projection indicates a need for an additional 32,430 du by 2015 (Table 3M-3).

Tehama County

Districts requesting CVP water for agricultural use in Tehama County include the Corning Water District, the Tehama Ranch Mutual Water Company, and the Rancho Seco Water District.

Population. This largely rural county has an estimated 1985 population of 43,800 (Table 3M-1). The county's primary population centers are Red Bluff (population 11,016) and Corning (population 5,149). DOF (1986) projects Tehama County's population to increase to 72,900 by 2015, which represents an annual 1985-2015 growth rate of 1.7 percent (Table 3M-2).

Housing. Tehama County's housing stock was estimated to be 18,600 du in 1985. The county's estimated housing vacancy rate was 11.1 percent at the beginning of 1985 (California Department of Finance 1986). Based on population projections and an estimated countywide average household size of 2.60 in 1985, Tehama County would require a total housing stock of approximately 29,780 du by 2015. This projection indicates the need for an additional 11,180 du by 2015 (Table 3M-3).

Glenn County

Agencies requesting CVP water for agricultural use in Glenn County include the Orland-Artois Water District, the Glide Water District, and the Kanawha Water District. The Glenn-Colusa Irrigation District, which is also requesting CVP water, is partially located in Glenn County.

Population. Glenn County's 1985 population was estimated to be 22,950 (Table 3M-1). The county's primary population centers are Willows (population 5,050) and Orland (population 4,497). DOF (1986) projects Glenn County's annual percentage growth rate to slow to 1 percent between 1985 and 2015, with the county's population reaching 31,100 by 2015 (Table 3M-2).

Housing. Glenn County's housing stock was estimated to be 9,170 du in 1985. The county's estimated housing vacancy rate was 8.8 percent at the beginning of 1985 (California Department of Finance 1986). Based on population projections and an estimated countywide average household size of 2.69 in 1985, Glenn County would require a total housing stock of approximately 12,200 du by 2015. This projection indicates the need for an additional 3,030 du by 2015 (Table 3M-3).

Colusa County

Agencies requesting CVP water for agricultural use in Colusa County include the Holthouse Water District, the Willow Creek Mutual Water Company, and the Colusa County Water District. The Glenn-Colusa Irrigation District is partially located in Colusa County.

Population. The population of Colusa County was estimated to be 14,450 in 1985 (Table 3M-1). The county's primary population centers are Colusa (population 4,539) and Williams (population 1,731). DOF (1986) projects Colusa County's population to increase to 22,100 by 2015, which represents an annual 1985-2015 growth rate of 1.4 percent (Table 3M-2).

Housing. Colusa County's housing stock was estimated to be 5,870 du in 1985. The county's estimated housing vacancy rate was approximately 12 percent (California Department of Finance 1986). Based on population projections and an estimated countywide average household size of 2.74 in 1985, Colusa County would require a total housing stock of approximately 8,660 du by 2015. This projection indicates the need for an additional 2,790 du by 2015 (Table 3M-3).

Yolo County

Agencies requesting CVP water for agricultural use in Yolo County include the Dunnigan Water District and the Yolo-Zamora Water District. The Cities of Davis and Woodland are requesting water for M&I use through the Yolo-Solano CVP Water Service Coordinating Group.

Population. Yolo County's population was estimated to be 122,600 in 1985 (Table 3M-1). The county's primary population centers are Davis (population 40,400) and Woodland (population 33,050). SACOG (1988) projects Yolo County's population to increase to 182,400 by 2010, indicating an annual growth rate of 1.5 percent between 1985 and 2010. Continued growth at SACOG's projected rate would lead to a population of 194,400 by 2015 (Table 3M-2).

Housing. Yolo County's housing stock was estimated to be 47,410 du in 1985. The county's estimated housing vacancy was 4.7 percent at the beginning of 1985 (California Department of Finance 1986). Based on population projections and an estimated countywide average household size of 2.55 in 1985, Yolo County would require a total housing stock of approximately 75,560 du by 2015. This projection indicates the need for an additional 28,150 du by 2015 (Table 3M-3).

Solano County

Entities requesting water for M&I use in Solano County through the Yolo-Solano CVP Water Service Coordinating Group include the cities of Dixon, Vacaville, Fairfield, Vallejo, Benicia, Rio Vista, Suisun City; the Solano Irrigation District; the Solano Flood Control and Water Conservation Districts; and the unincorporated industrial area of Collinsville.

Population. The population of Solano County was estimated to be 271,000 in 1985 (Table 3M-1). The county is highly urbanized along Interstate 80, with large population centers in Vallejo (population 89,500), Fairfield (population 65,900), and Vacaville (population 50,200). ABAG (1987) projects Solano County's population to increase to 435,500 by 2005, indicating an annual population growth rate of 2.2 percent. Continued growth at the rate projected by ABAG would bring Solano County's population to approximately 519,000 by 2015 (Table 3M-2).

Housing. Solano County's housing stock was estimated at 93,750 du in 1985. The county's estimated housing vacancy rate was 3.4 percent in 1985 (California Department of Finance 1986). Based on population projections and an estimated countywide average household size of 2.87 in 1985, Solano County would require a housing stock of approximately 180,190 by 2015. This projection indicates a need for an additional 86,440 du by 2015 (Table 3M-3).

Cities

City of Davis

Population. The City of Davis's population was estimated to be 40,400 in 1985 (Table 3M-1). SACOG (1988) projects Davis to grow to 69,900 by 2010, indicating an annual growth rate of 2.1 percent. Continued growth at SACOG's projected rate would increase the city's population to 75,800 by 2015; however, the City of Davis recently adopted an ultimate growth boundary which would limit its ultimate population to approximately 74,700 (Table 3M-2).

Housing. Davis had an estimated housing stock totaling 16,440 du in 1985. Davis had an estimated housing vacancy rate of 3.4 percent in 1985 (Department of Finance 1986). Based on population projections and Davis' estimated average household size of 2.41 in 1985, the city would require a total housing stock of 30,670 by 2015. This projection indicates a need for an additional 14,2300 du by 2015 (Table 3M-3).

City of Woodland

Population. Woodland's estimated population was 33,050 in 1985 (Table 3M-1). SACOG (1988) projects Woodland to grow to 55,700 by 2010, indicating an annual growth rate of 2 percent. Continued growth at SACOG's projected rate would increase the city's population to 60,300 by 2015 (Table 3M-2). The City of Woodland has no policy that would limit or slow population growth within existing or future city boundaries. (Nies pers. comm.).

Housing. Woodland had an estimated housing stock totaling 12,210 du in 1985. Woodland had an estimated 1985 housing vacancy rate of 3.9 percent (California Department of Finance 1986). Based on population projections and Woodland's estimated average household size of 2.72 in 1985, Woodland would require a total housing stock of approximately 22,240 by 2015. This projection indicates a need for an additional 10,030 du by 2015 (Table 3M-3).

City of Dixon

Population. The City of Dixon's population was estimated at 9,550 in 1985 (Table 3M-1). ABAG (1987) projects Dixon to grow to 14,900 by 2005, indicating an annual growth rate of 1.9 percent. Continued growth at ABAG's projected rate would increase the city's population to 17,000 by 2015 (Table 3M-2). The City of Dixon has no policy that would limit or slow population growth within existing or future city boundaries; however, the city council recently adopted a general plan measure that limits increases in the city's apartment stock to 3 percent per year. This measure could slow population growth within the city.

Housing. Dixon had an estimated housing stock totaling 3,140 du in 1985. Dixon had an estimated 1985 housing vacancy rate of 4.3 percent (California Department of Finance 1986). Based on population projections and Dixon's estimated average household size of 3.18 in 1985, Dixon would require a total housing stock of approximately 5,480 by 2015. This projection indicates a need for an additional 2,340 by 2015 (Table 3M-3).

City of Vacaville

Population. The City of Vacaville is Solano County's third largest city, with an estimated 1985 population of 50,200. ABAG (1987) projects Vacaville to grow to 97,300 by 2005, indicating an annual growth rate of 2.9 percent. Continued growth at ABAG's projected rate would increase the city's population to 118,300 by 2015 (Table 3M-2). The

City of Vacaville maintains a limited growth policy for apartment units, imposed after the city's apartment vacancy rate reached 21 percent in March, 1987. The vacancy rate has decreased substantially since then, but the policy remains in effect (Learned pers. comm.). Maintaining this policy could slow Vacaville's population growth rate.

Housing. Vacaville had an estimated housing stock totaling 16,600 du in 1985. Vacaville had an estimated housing vacancy rate of 3.6 percent (California Department of Finance 1986). Based on population projections and Vacaville's estimated average household size of 2.88 in 1985, Vacaville would require a total housing stock of approximately 40,290 by 2015. This projection indicates a need for an additional 23,690 du by 2015 (Table 3M-3).

City of Fairfield

Population. The City of Fairfield is Solano County's second largest city, with an estimated 1985 population of 65,900. ABAG (1987) projects Fairfield to grow to 116,100 by 2005, indicating an annual growth rate of 2.5 percent. Continued growth at ABAG's projected rate would increase the city's population to 138,300 by 2015 (Table 3M-2). The City of Fairfield has no policy that would limit or slow population growth within existing or future city boundaries.

Housing. Fairfield had an estimated housing stock totaling 21,380 du in 1985. Fairfield had has an estimated housing vacancy rate of 1.8 percent (California Department of Finance 1986). Based on population projections and Fairfield's estimated average household size of 2.96 in 1985, the city would require a total housing stock of approximately 45,880 by 2015. This projection indicates a need for an additional 24,500 du by 2015 (Table 3M-3).

City of Suisun City

Population. Suisun City's population was estimated to be 13,900 in 1985 (Table 3M-1). ABAG (1987) projects Suisun City to grow to 34,500 by 2005, indicating an annual growth rate of 3.5 percent. Continued growth at ABAG's projected rate would increase the city's population to 38,900 by 2015 (Table 3M-2). Suisun City has no policy that would limit or slow population growth within existing or future city boundaries.

Housing. Suisun City had an estimated housing stock totaling 4,410 du in 1985. Suisun City had an estimated housing vacancy rate of 5.0 percent in 1985 (California Department of Finance 1986). Based on population projections and Suisun City's estimated average household size of 3.33 in 1985, the city would require a total housing stock of 11,920 du by 2015. This projection indicates a need for an additional 7,510 du by 2015 (Table 3M-3).

City of Vallejo

Population. The City of Vallejo is Solano County's largest city, with a 1985 estimated population of 89,500. ABAG (1987) projects Vallejo to grow to 119,400 by 2005, indicating an annual growth rate of 1.2 percent. Continued growth at ABAG's projected rate would increase the city's population to 129,700 by 2015 (Table 3M-2). The City of Vallejo has no policy that would limit or slow population growth within existing or future city boundaries.

Housing. Vallejo had an estimated housing stock totaling 32,490 du in 1985. Vallejo's estimated 1985 housing vacancy rate was of 3.4 percent was virtually the same as the countywide rate in that year (California Department of Finance 1986). Based on population projections and Vallejo's estimated average household size of 2.76 in 1985, the city would require a total housing stock of approximately 47,070 by 2015. This projection indicates a need for an additional 14,580 du by 2015 (Table 3M-3).

City of Benicia

Population. The City of Benicia's population was estimated to be 20,850 in 1985 (Table 3M-1). ABAG (1987) projects Benicia's population to reach 28,600 by 2005, indicating an annual growth rate of 1.4 percent. Continued growth at ABAG's projected rate would increase the city's population to 32,000 by 2015 (Table 3M-2). The City of Benicia has no policy that would limit or slow population growth within existing or future city boundaries.

Housing. Benicia had an estimated housing stock totaling 7,760 du in 1985. Benicia's estimated 1.4 percent housing vacancy rate was the lowest rate in the county in 1985 (California Department of Finance 1986). Based on population projections and Benicia's estimated average household size of 2.72 in 1985, Benicia would require a total housing stock of 11,860 du by 2015. This projection indicates a need for an additional 4,100 by 2015 (Table 3M-3).

City of Rio Vista

Population. The City of Rio Vista's population was estimated to be 3,400 in 1985. ABAG (1987) projects Rio Vista's population to reach 9,000 by 2005, indicating an annual growth rate of 3.9 percent. Continued growth at ABAG's projected rate would increase the city's population to 10,700 by 2020 (Table 3M-2). The City of Rio Vista has no policy that would limit or slow population growth within existing or future city boundaries.

Housing. Rio Vista had an estimated housing stock totaling 1,450 du in 1985. The city's estimated housing vacancy rate was a relatively low 2.9 percent in 1985 (California Department of Finance 1986). Based on population projections and Rio Vista's estimated average household size of 2.42 in 1985, the city would require a total housing stock of approximately 4,460 du by 2015. This projection indicates a need for an additional 3,010 du by 2015 (Table 3M-3).

C-055649

CULTURAL RESOURCES

Sacramento River Service Area

Introduction

This section describes the cultural resources of the SRSA. It focuses primarily on the cultural resources located within the Shasta Reservoir pool area that could be affected by modified reservoir operations associated with the water contracting alternatives. In addition, information about Native American use of the Trinity River is provided because the Hoopa Valley Indian Tribe is concerned about the effects of water contracting on Trinity River fisheries on reservation lands. Finally, cultural resource sites listed on the National Register of Historic Places and located in or near requesting agencies are presented.

Prehistory

Prehistoric sites within the Shasta Reservoir area include both transitory camps and sedentary villages. These sites are commonly described as belonging to the Shasta complex, as defined by Meighan (1955). Shasta complex sites are recent with settlements typically located by streams. The sites commonly contain remains of semisubterranean houses and acorn processing in hopper mortars (Meighan 1955).

Shasta complex sites are believed to be associated with the Wintu people, who spread from the north into the northern part of the Central Valley. Common Shasta complex features are saucer-shaped pits, some of which are the remains of dance houses. A large number of flexed burial sites are also associated with this complex. Burial sites are often found with Haliotis shells, pine nut beads, arrow shaft smoothers, and Gunther Barbed arrow points.

In the Shasta Reservoir pool area, 110 prehistoric sites have been identified (Henn and Sundahl 1986), 105 of them prehistoric and five prehistoric sites with historic components. The first 37 sites were located in 1941 prior to the construction of Shasta Dam (Smith and Weymouth 1952); the remainder were recorded over the past 45 years. Three of the 37 sites originally recorded were test excavated, and 38 burials were recovered from the excavations. Only an estimated 10 percent of the reservoir shore has been examined for cultural resource sites (Henn and Sundahl 1986). However, because much of the reservoir is surrounded by steep slopes, the potential for finding prehistoric or historic sites in many areas is low (Peak & Associates 1983).

All 110 prehistoric sites lie below or partially below the high water mark of 1,067 feet (Henn and Sundahl 1986). Of that number, 54 are located along the McCloud arm of the reservoir, 26 along the Pit River arm, 22 along the Sacramento River branch, and eight along the Squaw Creek arm of Shasta Reservoir (Henn and Sundahl 1986). Most sites are

C-055650

within 200 feet of the reservoir shore and are located predominantly on terraces (46 percent), ridges (26 percent), and gentle slopes (26 percent).

Evidence of housepits was found at 21 sites, and 49 sites included plant processing equipment (Sundahl 1986). The majority of projectile points collected from the sites were arrow points of the Gunther Barbed and Desert Side-Notched varieties, indicating the sites date to the last 1,000 years. Large side-notched and leaf-shaped points, which were used with the atlatl, were also found, suggesting the area has been used for at least the last several thousand years. The research potential of the sites was assessed by the U.S. Forest Service in 1986 as follows: 24 were rated as high, six as moderate, 11 as low, and 74 as unknown (Henn and Sundahl 1986).

Native American Groups

The Shasta Reservoir area was occupied by four subgroups of Wintu Native Americans. The Nomtipom lived along the upper Sacramento River, the Wenemem and the Waimuk along the McCloud River, and the Puisus on the banks of the Pit River (DuBois 1935). Wintu villages were built on level ground next to rivers and consisted of several bark houses that were conical in shape. The floor of this single family dwelling was slightly excavated into the ground. Wintu people relied heavily on salmon and trout, which they caught with spears. Salmon was dried and remained a stable food source throughout the winter.

The Central Yana Indians also inhabited the Shasta Reservoir area and lived predominantly along the Cow Creek drainage. Yana villages were built along small creeks, and their dwellings housed two or more families. Fishing was important to the Yana also; they claimed three fishing stations in the Shasta Reservoir area.

According to Peak & Associates (1983), 125 ethnographic/ethnohistoric sites are recorded in the vicinity of Shasta Reservoir. These sites consist of 35 villages, 14 cemeteries, five dance houses, ceremonial sites, four battlefields, 20 trails, and 20 fishing stations. Peak & Associates contacted the Native American Heritage Commission during its 1983 investigation and found the commission was concerned about several cemetery and ceremonial sites located around the reservoir. A contemporary Native American allotment, Roaring Creek Rancheria, is situated one mile from the reservoir.

The Trinity River area was occupied by the Hoopa and Yurok Native American Tribes at the time of historic contact. Today the Hoopa Valley Indian Reservation is located along the South Fork of the Trinity river. The Hoopa Tribe currently holds the White Skin Deer Dance and the Boat Dance along the Trinity River. Fish taken from the Trinity River are used during ceremonies held by the Yurok and Hoopa Tribes. Fishery resources from the river are an integral part of the cultural heritage of the two tribes.

History

Some of the first visitors to the Shasta Reservoir area were Hudson Bay Company trappers who explored much of what is now Shasta County in 1829. In 1835, a trail was blazed along the base of Mt. Shasta to the Sacramento Valley to the south. The trail was referred to as the Shasta branch of the Oregon Trail and was used by trappers through the 1940s (Sundahl 1986). Gold was discovered along Clear Creek in 1848, resulting in a great influx of people into the mountainous Shasta region. Much of the gold mining occurred west of Shasta Reservoir in the districts of Whiskeytown, Shasta, Iron Mountain, and Old Diggin's (Sundahl 1986). Many of the historic resources in the Shasta area are related to mining activities. Other important historic resources include the Oregon Trail and Redding-Yreka stage road, the Lakehead, Bully Hill, and Gibson Creek cemeteries, and numerous townsites such as Lamoine, Pollock, Bayles, Delta, DeLamar, and Lakeshore.

The U. S. Forest Service has recorded 10 historic sites within the pool area of Shasta Reservoir (Sundahl 1986). Five of these sites also have prehistoric components. The majority of historic sites are located in canyons adjoining the rivers in the southern portions of the reservoir. Many additional unrecorded sites are thought to exist below the high water mark because early inventories focused on locating prehistoric rather than historic sites. Peak & Associates (1983) conducted an inventory of historical resources within the pool area and 200 feet above it, and found 60 historic sites. Many of these were listed in historic records but have not been verified on the ground.

Sites recorded by the USFS include the Town of Copper City and the Kennett Townsite. Both sites contain artifacts and machinery related to copper mining that first began in the area in 1862. Copper mining was extensive in the Shasta region and primarily occurred between 1896 and 1908. Nearly 708 million pounds of copper was produced from Shasta County mines between 1869 and 1965. In the 1890s, Kennett grew from 20 people to 2,500 people. During its boom in the early 1900s, Kennett maintained several hotels and saloons, a newspaper, and a bank (Sundahl 1986). Other sites recorded by the USFS include the Lost Buffalo, Muckracker, and O'Brien Inlet sites, all of which are historic habitation sites dating to the early 1900s.

An evaluation of the significance of the 10 sites recorded by the USFS indicates that three sites have a high research potential, and one has a low research potential. The remainder could not be evaluated based on current information (Henn and Sundahl 1986).

Site-Specific Service Areas

Information concerning sites listed on the National Register of Historic Places was compiled from the Federal Register, Vol. 53, No. 100, dated May 24, 1988, for the area encompassed by the Sacramento River water contracting area (Table 3N-1). The table includes only those sites in or near the water districts that appear on the register. Several cities have sponsored historic site inventories, but the national register status of these sites has not been determined (California Department of Parks and Recreation 1986).

In addition, several Conservation Corps buildings and structures eligible for national register listing are found within the Sacramento National Wildlife Refuge.

Table 3N-1. National Register Sites:

Sacramento River Service Area

Agency	National Register Site	Location
<u>Sacramento Valley Canals Agencies</u>		
Corning Water District	Bridge No. 8C-14	Carries Rawson Road over Red Banks Creek
	Bridge No. 5C-32	Carries Rawson Road over Thomes Creek
	Molino Lodge Building	3rd and C Streets, Tehama
Glenn-Colusa Irrigation District	Willows U. S. Post Office	315 W. Sycamore Street
	Colusa High School and grounds	745 10th Street
	Colusa Grammar School	425 Webster Street
<u>Yolo-Solano CVP Water Service Coordinating Group</u>		
Davis, City of	Dresbach-Hunt Boyer House	604 2nd Street
	Southern Pacific Railroad Station	H and 2nd Streets
	Joshua Tufts House	434 J Street
	Animal Science Building	University of California, Davis
Woodland, City of	William B. Gibson House	512 Gibson Road
	Porter Building	501-511 Main Street
	Woodland Opera House	320 2nd Street
	Woodland Public Library	250 1st Street
	R.H. Beamer House	19 3rd Street
	Woodland I.O.O.F. Building	723 Main Street
	James Moore House	SW of Woodland
	Nelson Ranch	Woodland vicinity between State Routes 113 and 102
Benicia, City of	Benicia Arsenal	Army Pt. and I-680
	Benicia Capitol Courthouse	1st and G Streets
	Crooks Mansion	285 W. G Street
	Old Masonic Hall	106 W. J Street
	S.S. Jeremiah O'Brien	Benicia vicinity, east of Suisun Bay
	Carr House	165 E. D Street
	Joseph Fischer House	135 G Street
Suisun City, City of	Suisun Masonic Lodge No. 55	623 Main Street
	Samuel Martin House	293 Suisun Valley Road
Vacaville, City of	Vacaville Town Hall	620 E. Main Street
	Pena Adobe	2 miles SW of Vacaville
	Will H. Buck House	301 Buck Avenue
Vallejo, City of	Mare Island Naval Shipyard (National Historic Landmark)	No specific locational information
	Vallejo City Hall and County Building Branch	734 Main Street
	Old City Historic District	Sonoma Boulevard and Monterey, Carolina and York Streets